SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXXVII
NUMBER 2260

NEW YORK, APRIL 26, 1919

Published weekly. Entered as second class matter, December 15, 1887, at the Post Office at New York, N. Y., under Act of March 3, 1879

10 CENTS A COPY
$5.00 A YEAR

One man to dig, load, and carry away

THE PORTABLE SCOOP CONVEYOR (see page 264)

Inorganic Complexes*

The Structure of Mineral Compounds Containing a Large Number of Atoms

By José Rodriguez Mourelo, Professor in the Madrid Industrial School

It is my purpose here to summarize the principal ideas set forth in the address read by me on the occasion of the inauguration of the section of Physico-Chemical Sciences at the Congress of the Spanish Association for the Advancement of Science, held at Valladolid. The subject of the said address was The Chemistry of Inorganic Complexes, and I must acknowledge to begin with that my choice of subjects was influenced by the work recently published by my very good friend, M. G. Urbain, professor at the Sorbonne, bearing the same title. I have found this admirable treatise a valuable source of inspiration and have made large use of the facts and ideas it contains, while at the same time attempting to add to them something of my own.

It is important to acknowledge in the beginning the assistance which has been given us by the experimental researches and theories of Professor A. Werner of Zurich, which have enabled us not merely to form a definite notion of the "complex" but also, in order to interpret the constitution of such aggregates, to apply to them the idea of molecular combination; and which have led us, furthermore, to modify profoundly the theory of valence by the introduction of what Professor Werner has termed *numbers of co-ordination*. In my opinion Urbain is quite correct in the definition which stands at the beginning of his book, to wit: "Every chemical compound whose formula contains a large number of atoms deserves the name of a complex." And the same authority adds that according to this definition all or nearly all combinations, with the exception of binary compounds, may, strictly speaking, be regarded as complexes. It is obvious, likewise, that if we adopt this interpretation organic chemistry is *par excellence* the science of complexes.

But the term complex has never been given so general a signification. The designation of complexes has been confined to certain special aggregates which group together numerous elements within their molecule, and which possess definite characters. To begin with, these aggregates must be either electrolytes or double salts, or must result from the intimate union of ions and molecules. It was thus that the earliest chemists, who were still under the influence of the dualist theory, regarded complexes.

Considered in their ensemble, those combinations which are called complexes in this restricted sense constitute an entirely new branch of chemistry. This branch is derived from what may be called "classic chemistry," but it is characterized by the technical difficulties involved in the preparation of complicated substances, many of which are not very stable, while others are subject to very curious changes and transformations. Its principles accord marvellously well with those of physical chemistry and with the newest concepts concerning chemical affinity. These special aggregates into which there enter certain definite metals, especially platinum, cobalt, chromium, copper, or iron, which constitute perhaps the bond of union sought by Wertz between the carbon compounds and those of metals, possess a singular structure, a sort of internal mobility which permits isomerisms and tautomerisms which are entirely analogous to those of the carbon compounds. And it is even the case that the fundamental nucleus of their molecule may be represented in space by the octahedron of Werner, which recalls the tetrahedron of Le Bel and of Van't Hof in relation to compounds of carbon.

A certain number of complexes, notably the chloroplatinites and the chloroplatinates, several ammoniometallic compounds (among which are the series which yield the ferrous and ferric cyanides and the cyanide of cobalt) and a number of other compounds of most various nature have long been a subject of study; they are all characterized by the circumstance that certain of their components cannot be detected by the usual reagents.

There are two distinct periods in the history of the study of complexes. The first corresponds to the discovery of new bodies which are distinguished from each other by their physical properties but all of which possess the characteristic feature that the components cannot be detected by their ordinary reagents. This important phenomenon is of frequent occurrence in certain families of compounds; it has suggested various interpretations and has immediately enabled us to assume that the atomic elements in complex combinations must be found in a state of grouping very different from that which they possess in more simple molecules. We may say with more or less precision according to the stability of the complex that the individuality of these elements is merged into the ensemble of the molecule.

To be convinced of the very great interest which has long been felt in the complexes and to comprehend the general evolution of the doctrine concerning them, we need only recall the researches of Magnus upon the chlorides of platinum (1828-1829), of Reiset, who discovered the two bases which bear his name and which he defined as true alkaline bases containing platinum (1844), of Gerhardt which likewise concerned platinic bases (1850), of Raewsky and of many other investigators who may be considered as the precursors of Frémy in his methodical studies upon the compounds of cobalt. The first stage corresponds to the establishment of a number of data and comprises almost no critical study. It then became essential to classify the bodies and arrange them in series according to their colors, which bear a definite relation to their composition. It was upon color, indeed, that Frémy based the classification of his complexes of cobalt; it is a well known fact, for example, that the purpureo-, roseo-, luteo-, and fusco-cobaltic salts correspond to an equal number of complex bases.

The chemistry of complexes has been much indebted to these researches; but however large the number of the facts thus collected and however great their experimental value, they were insufficient to solve the problem of complexes because they did not enable the chemist to obtain a clear idea of the structure of the molecules formed. The phenomena observed all possess the same general character; hence it was possible to conclude that the chemical constitution is identical in the complexes of platinum, of cobalt, or of chromium. These were then the best known and the most numerous. I have already observed that the color was the basis of classification in the cobalt series.

The inorganic complexes have been regarded from the point of view of the dualist theory. Let us consider a substance such as chloride of platinum to be a sort of nucleus. In certain conditions it may combine with another binary body of basic character and the ensemble will constitute the complex, provided it be endowed with certain properties which are determined qualitatively by the stability of the body. The hydroxide of cobalt forms with ammonia one or more combinations which behave like special ammoniacal bases, and it is in this sense that they combine with acids to give special salts, complexes of very various kinds. The same thing is true in the case of iron, of chromium, of copper, and of all the other metals which are capable of forming similar combinations. In every case the result seems to be accomplished by means of the singular union of binary combinations with others of the same kind; it is solely the character of the bond which impresses their quality of complexes upon the resultant aggregates.

The present classifications of the complexes are based upon what we may term the field of existence of each of them, or each group of them, speaking generally, and upon the chemical confines of a constituent element. By this we mean that the chemical equilibrium of the components constitutes the definite controlling factor in the existence of the complexes. But since this equilibrium is not a static and inert equilibrium, but is capable of motion between variable limits, it results therefrom that the complex systems must be differentiated according to the conditions of their existence or their limits.

In accepting these ideas we must assume that no molecular aggregate is fixed except in very special conditions; the equilibrium varies in one direction or the other within more or less extensive limits; but it moves and changes in passing from one to the other. The consequence of this is that in reality a molecular aggregate must co-exist with the products of its own disintegration; and when the proportions of these are insignificant or inappreciable we declare that the system is stable, thus considering the chemical species to be defined solely by the greater extension of the fields of existence, because their evolution and their transformations are slower and less perceptible. This compels us to believe that the law of denite proportions itself, like all the other fundamental laws, must be considered as holding in the limit only. There is, however, within the interior of the molecule a sort of energy which I will call "energy of union," which manifests itself by a resistance to change, particularly within the limits of the field of existence of the system. It has a positive and variable value which continually resists the external causes that tend to produce modifications; and this value up to a certain point is sufficient to prevent that disintegration of the system whose germs reside within the system itself from the moment of its formation.

Another hypothesis must be recalled at this point since it supports the established theories concerning complexes. In a very general sense the bodies thus denominated may be regarded as metastable systems, and their classification is based upon their degree of stability. This stability governs the course of their evolution. In the complexes of platinum the internal modifications of the molecular aggregate are sometimes accomplished very slowly; sometimes on the contrary they are more rapid; but the point is that they always occur, and every complex is the seat of continual transformations which are doubtless due to the peculiar structure of its molecules and the method of its formation, a circumstance which must be taken into account and which in my opinion has as yet not received sufficient consideration as regards its general aspects.

Besides these general ideas which are indispensable features of the theory of complexes we must take into consideration likewise other ideas which more nearly concern their constitution. In the first place it may be affirmed that every complex is characterized by the fact that it is a molecular combination. Its structure results from the aggregation of simpler molecules. This circumstance furnishes an explanation of the anomalous fact which has long been observed that the metals contained in the complex cannot be detected by their usual reagents; they no longer exist in the shape of metals, in fact, but under the form of special conglomerates, of incomplete molecules, more or less disassociated, and also of ions; and their ensemble cannot be determined by analysis in the manner in which any metal can be determined in any *atomic* combinations whatever. It is doubtless for this reason that the inorganic complexes are believed to contain *compound radicals*. This hypothesis entirely confirms the idea of regarding them as true metastable species.

It should be observed that this property possessed by complexes of not revealing their components through the action of the reagents proper to them exhibits itself in different degrees. We say in general when a metal is not precipitated by its usual reagents that it is disguised (*dissimulé*); but this disguise may be either total or partial and depends upon variable causes such as the nature of the metal contained in the complex, that of the negative ion, and that of the disguised molecule itself.

Having obtained a clear idea of the nature of inorganic complexes we must now take note of certain delimitations of grouping which are clearly evident and which mark the evolution of the associations of molecules. There exists a sort of gradation which is the result of the greater or less amount of energy in the molecular unions, and which may be taken as a basis of classification of complexes, even without that knowledge of the structure of the groups which is deduced from their individual and specific properties. Consequently the classification in question may be regarded as entirely justifiable and it even possesses a quantitative character up to a certain point, while at the same time it indicates the peculiarities in the development of complexes as revealed in the properties they possess as well as by the manner of formation of each system.

It has long been observed in ordinary combinations that in proportion as their degree of complexity increases the constituent elements suffer a loss of their individuality; at the same time the stability of the system diminishes in proportion as the bonds of union become more complex; this is the case, for example, in the organic compounds. We may say in general that the stability of equilibrium is connected with the simplicity of the molecule and with that of the bonds of union between the constituent atoms. But there are a number of cases in which the atomic groups exhibit a tendency to transform themselves into molecular combinations, which is explained by the comparative facility with which certain elements form complex ions. As an example of the formation of these aggregates we may mention a certain number of double salts, such as the alums, certain aluminates, and the compounds called spinels.

It would certainly be over-bold to give the name of

*Translated for the Scientific American Supplement.

complexes in the most restricted sense to the double salts, which are on the whole addition compounds of highly radiant stability; but it is none the less certain that they constitute as it were the first term of the evolution which leads up to the compounds which are denominated "perfect complexes." Here we have therefore the three species of molecular aggregates with which we are concerned classified according to their general properties: The double salts, the imperfect complexes, and the perfect complexes, whose differences reside in the energy of union, or, to state the latter more fully, in the numerical value of the energy which keeps united the various molecules constituting the complex.

It must be admitted that a dualist representation is better applicable in the case of the double salts; this is evident when we take into account the structure of certain double or multiple anhydrous or hydrated silicates which are found in nature in the free state or as an integral part of rocks. From this point of view certain resemblances are apparent between the double and the complex salts, provided we regard the double salts as being the final product of the degradation of a perfect complex. And the resemblance is still more perfect when we consider likewise the great sensitiveness which double salts exhibit to external influences, which modify them and sometimes destroy them. However this resemblance ceases at this point and differences make their appearance in the field of existence of the two groups as concerns its extent and its value.

It is easy to understand how in passing from the most alterable aggregates to the perfect complexes such as those in the platinum series, a long series of intermediate states will naturally be found which are characterized by the extension of their field of existence—aggregates possessing an equilibrium less mobile than that of the double salts, which contain ions having very different degrees of disguise. The complexes of chromium are comprised in their number, which is very considerable.

The chromium complexes belong in general to the category of imperfect complexes and suggest many interesting questions such as those concerning the coloration of the salts of chromium and their hydrolysis. In this connection we will mention the study of the chlorides of chromium and of their solutions and the degrees of disguise of the radicals in the imperfect complexes. At this point, too, we must take note of the tautomerism, in that the quantity of chromium precipitated depends upon the reagent employed, and it appears that we are here concerned with substances of different composition. The experiments of Weinland and Koch, the researches of Recoura, and those previously made by Peligot and by Wyrouboff, as well as those of Werner with regard to the products of transformation of the chromium compounds, are conclusive, and establish a bond between organic and inorganic chemistry which is all the closer because the case is not unique.

We may accept it as a fact that evolution of the complexes finds its most complete development in the perfect complexes, the best examples of which are the platinum series and the cobalt series. These are definite non-transitory systems, characterized by the total disguise of metallic radicals of the nucleus of the molecules. The simple metals do not appear; their individuality is lost from the moment when they contract the molecular alliances which constitute the complex.

The perfect complexes may be defined as metastable systems capable of all sorts of transformations, which take place more slowly, however, than those of the other complexes, by reason of the extension of their field of existence. According to this definition ammonia becomes a perfect complex; it is very stable and its components, nitrogen and hydrogen, cannot be detected by means of reagents. Likewise ammonia is the starting point of a large number of complexes.

It would be a serious mistake to attempt to establish definite limits between the perfect and the imperfect complexes, or even between the different groups. These limits are not inherent in the molecular constitution of aggregates and do not depend upon external causes. The stability and consequently the field of existence are conditioned in each case by a relation, which is not always appreciable, between the interior and the exterior, between the mobility of equilibrium of the system and the external action whose effect would be to disturb it by disintegrating the molecule of the complex either partially or totally.

In his exposition of the theories concerning complexes Urbain awards the high rank which they deserve to the researches of Blomstrand and of Joergensen, which preceded those of Werner; and he declares that the first named of these scientists was the founder of the theory of complexes by means of the happy application of methods which yielded such admirable results in the chemistry of the compounds of carbon. The starting point of the theory is based upon the idea of the principal and the secondary valences, assuming that the chain formation of the molecules of ammonia in the complex inorganic salts takes place by means of the secondary valences, to the number of two for nitrogen, provided, however, that no ammonia molecules shall be placed at the extremities of the chain and assuming also all possible substitutions in the radicals which occupy these extreme positions. According to Blomstrand, platinum, cobalt, chromium, and the other metals which are analogues of these with respect to the property of forming complexes, all of which are but slightly electro-positive, exhibit a peculiar aptitude for such substitutions.

In spite of its very wide scope this first conception is inadequate. Only the principle of it survives because the point of departure of later theories is always the idea of the valence. Joergensen, while examining certain series of complex cobaltic salts, and some of their chlorine derivatives, with the intention of observing the degree to which the chlorine was disguised, demonstrated that in the chloro-purpureo salts the chlorine is directly united to the heavy metal; and in this fact we have another point of departure which has enabled us to modify the representation of complexes and to establish an important system of notation.

Thanks to these preliminary investigations Werner was able to develop his concepts and to introduce new ideas by enlarging the limits of the theories of valence, by ingenious applications of ionic formulas, and by the introduction into organic chemistry of such important ideas as that of dissymmetry. Furthermore, Werner has deduced a fundamental form of representation of complex molecules and his octahedron is of as great value as the tetrahedron of carbon is in organic stereochemistry. I must here confine myself to the mere exposition of the theory and a few of its applications.

In the work of Werner we find one predominating idea and various applications. This is the idea of the valences which he terms valences of coordination and which he has employed in order to establish the unitary formulas of complexes. Joergensen had proposed a system of formulas derived from similar principles which he had applied to the complexes of cobalt; and Werner by a happy extension of the doctrines of Arrhenius succeeded in expressing the structure of complex molecules by means of ionic formulas. He assumes two kinds of valences; electrolytic valence and intra-ionic valence, the latter being the valence of coordination. Any metallic atom whatever is capable of uniting with various ions or with complete molecules; the number of the ions, or of the molecules, is the index of coordination. Thus is stated the principle which enables us to establish the ionic formulas of the complexes.

A scientific theory so general in its application must be founded upon a large number of facts and must be able to explain them, to represent them, and foretell them, conditions which Werner's concept fulfils in large measure. The idea of the valence of coordination is deduced from observed facts and from the theory of ions; it is intimately concerned with the atoms of the heavy metals which are capable of forming complexes and which are but slightly electropositive, and in some cases it indicates a particular state of the metallic element. For example, cobalt forms two classes of saline compounds. In one of these it preserves its relationship with nickel and in the other it lends itself to the formation of ammonia compounds. The creation of these intra-ionic valences the existence of which serves to explain the constitutional complexes appears to be determined by the medium and the actions of the elements, the molecules, or the ions. The idea may be still further developed. Each of the metallic elements is capable of uniting, by means of its valences of coordination, with a definite number of ions or of complete molecules and such a number has a considerable value in the theory.

It results from this that the indexes represented by these numbers measure the capacity of the metallic element to form complexes and since the ion, or the molecules united to the metal by their valences of coordination are variable it is easy to understand the possibility of substitution; and also how a series of derivatives of indefinite number may correspond to each type of complexes, each derivative being capable in its turn of forming the origin of new series, as has been shown in the case of platinum and of cobalt.

At this point it is worth while to quote the text of Urbain with reference to the fundamental idea of coordination. "The mere inspection of the ionic formulas of Werner suggests the following reflections. Every cobaltic complex containing only one atom of cobalt—whether this complex be an ion or even a non-electrolytic molecule—contains besides the said atom of cobalt six groups which may be, indistinctly, entire molecules. The complex ion is negative when it contains less than three entire molecules. The complexes which contain three entire molecules are not electrolytes. One entire molecule such as that of ammonia or of water can be replaced in a complex by a monovalent ion which remains disguised with respect to its usual reagents only in the perfect complexes. This substitution lowers the valence of the complex ion by one unit, if this ion be negative. The cobaltic complex ions are trivalent at most whatever be their sign." It should be added that the atoms of the other metals in the complexes are capable of being substituted for each other and that the valence is not permanent; Werner established the fact that the molecules of ammonia are capable of being replaced by monovalent ions in order to form a series whose valence decreases till it becomes zero and then increases up to three, as is proved by the measurements of conductibility.

It is evident that the doctrines of Werner have a very great tendency towards generalization and it is easy to comprehend why this should be so. Let us consider any complex whatever formed by the atom of metal and the molecules which are united by the valences of coordination; if we replace these molecules by others or by the same metal a new substance will result and the process enables us to pass from one to the other. The transformations of the various complexes of cobalt and the formation of series of bodies having their starting point in other series constitutes the proof of this.

The imagination of great innovators always flies high and wide and rarely descends to small details. However it is just in these details that the most serious difficulties are often found. If the indexes of coordination were fixed for each substance, if the number six of platinum occurred in all its ammonia compounds and in its multiple derivatives, if the principles stated had no exceptions and if all complexes belonged in the category of the perfect complexes then Werner's concept would likewise be quite perfect. The idea formulated by him is great and luminous; it has shed light upon many problems and it has given a more scientific character to the chemistry of complexes; it is general in its applications but not so much so as it ought to be.

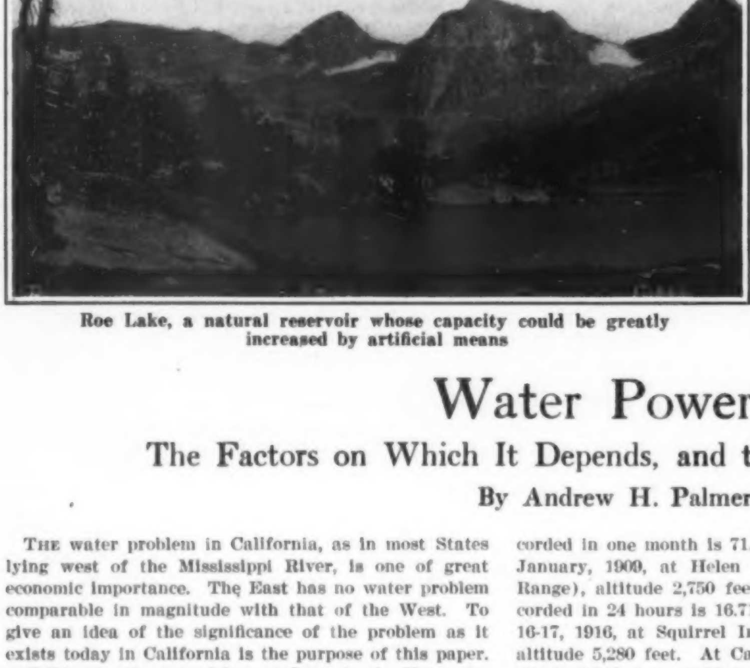
But the objections offered to Werner's theory tend rather to support it than to discredit it since they prove that evolution of the theory of complexes has not yet come to an end and it is necessary to work towards its complete development. In my own opinion this great concept of Werner's with the unity of his formulas is imperfect by reason of its rigidity, a fault of which all excessively general doctrines are guilty. It has little flexibility and cannot be accommodated to the explanation of certain phenomena without a considerable degree of violence. This can be shown by an example borrowed from Urbain. From the point of view of substitutions in complexes water and ammonia can be considered as having similar functions and it is a well known fact that in solution the hydrates are considerably less stable. I do not mean to say that the hydrates form an exception in being perfect complexes. However, Werner's doctrine concerning the valences of coordination and the indexes represents the greatest progress made in the chemistry of complexes up to the present time.

From every point of view the theory is of vast interest especially in all that concerns the isomerism of complexes.

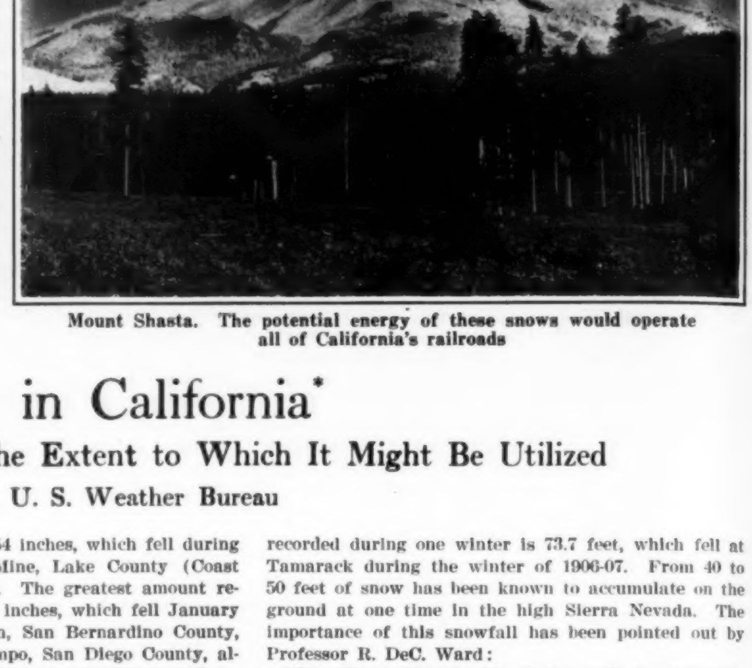
We can readily understand that the same empirical formula may be adapted to various ionic formulas representing an equal number of complexes which, while possessing the same percentage composition exhibit a different molecular structure. The existence of isomeric complexes is an experimental fact and their representation by formulas is possible because of this molecular structure. In the cobalt series there exist isomers having as high as five atoms of metal; other molecules contain four atoms of cobalt, six hydroxyl groups and up to twelve molecules of ammonia; and still other isomers are formed when, in a body whose ions contain atoms of different metals, one of these metals is replaced by another in the ions having the contrary sign. Besides this there exist other isomers which may be said to be privatives of complexes.

In some cases the only question is concerned with the particular molecular form, in others with the influence of water, and in the last with the relations of the valence. Werner assumes three sorts of these modifications: metamerism of ionization, isomerism of hydration, and isomerism of valence. The first is produced every time that a negative ion changes place in a complex with a positive ion, the first being simple and the second being complex. The isomerism of hydration

(*Continued on page 272*)



Roe Lake, a natural reservoir whose capacity could be greatly increased by artificial means



Mount Shasta. The potential energy of these snows would operate all of California's railroads

Water Power in California*

The Factors on Which It Depends, and the Extent to Which It Might Be Utilized

By Andrew H. Palmer, U. S. Weather Bureau

THE water problem in California, as in most States lying west of the Mississippi River, is one of great economic importance. The East has no water problem comparable in magnitude with that of the West. To give an idea of the significance of the problem as it exists today in California is the purpose of this paper.

California, the second largest State in the Union, includes approximately 160,000 square miles of the extreme southwest of the United States. Its latitude is equivalent in range to that part of the Atlantic coast extending from Boston to Savannah. Partly because of its position and partly because of its diversified topography it is a region of great climatic contrasts.

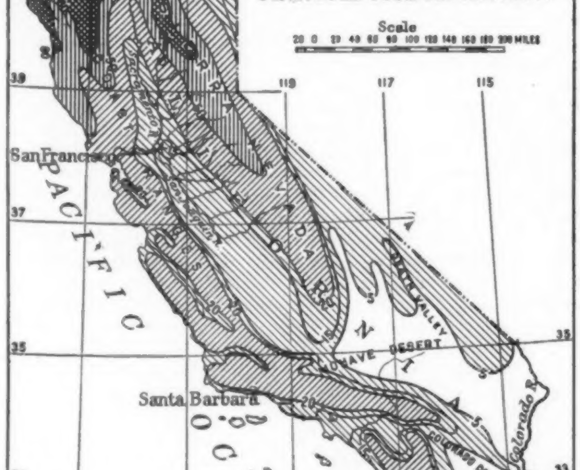
THE RAINFALL.

Precipitation, the only element of climate here considered, ranges from one or two inches per year, on the average, in the Mohave Desert, to more than 100 inches pear year in the Sierra Nevada Mountains. Within the State are also included the region of greatest known snowfall in the United States and regions in which snow of measurable amount has never been known to fall.

Figure 1 is an outline map of California showing the average annual precipitation in inches. It is readily apparent from the figure that there is a general increase in average precipitation from the southeast to the northwest and, furthermore, that the mountains are regions of heavy precipitation, while the interior basins and the southeastern plateau regions have deficient precipitation. Records show that there is an increase in average annual precipitation up to a height of 5,000 feet in the Sierra Nevada, and a decrease above that height. The average annual rate of increase up to 5,000 feet is about 8.5 inches for every 1,000 feet. The ultimate source of practically all the rainfall in California is the Pacific Ocean. As the moisture from it is brought in by westerly winds, the eastern and northeastern slopes of the mountains receive much less precipitation than the western and southwestern slopes [1], [2]. The rainfall is unequally distributed throughout the year, winter being the wet season, and summer the dry season. Toward the north the distribution of rainfall through the year becomes more nearly equalized. In southern California about 90 per cent. of the annual precipitation occurs during the winter half-year, while in northern California the proportion is about 75 per cent.

The heaviest recorded precipitation for a calendar year in California is 156.90 inches, which occurred in 1911 at La Porte, Plumas County (Sierra Nevada), altitude 5,000 feet. Nearly every year at one or more stations precipitation is recorded exceeding 100 inches. As the greater part of the annual precipitation occurs during six months, extraordinary amounts sometimes fall within short intervals. The greatest amount recorded in one month is 71.54 inches, which fell during January, 1909, at Helen Mine, Lake County (Coast Range), altitude 2,750 feet. The greatest amount recorded in 24 hours is 16.71 inches, which fell January 16-17, 1916, at Squirrel Inn, San Bernardino County, altitude 5,280 feet. At Campo, San Diego County, altitude 2,543 feet, 11.50 inches of rain fell in 1 hour and 20 minutes, on August 12, 1891. The significance of these figures is apparent when it is realized that one inch of rain is equivalent to more than 100 tons of water to the acre.

By way of contrast, consider the record of Bagdad, San Bernardino County, altitude 784 feet, where no measurable rain fell from October 3, 1912, to November 8, 1914, inclusive—a period of more than two years.



Map of California showing annual precipitation in inches. Scale, 1:8,000,000

At Indio, Riverside County, 20 feet below sea level, no measurable rain fell from November, 1893, to January, 1895, a period of more than a year. At several stations in the Imperial Valley and at one in Death Valley, both of which depressions are below sea level, there have been periods of a year in which less than an inch of rain fell.

SNOWFALL.

Since most of the precipitation comes during the winter season the elevated portions of the State have abundant snowfall. Tamarack, Alpine County (Sierra Nevada), altitude 8,000 feet, has an average winter snowfall of 43.4 feet, based upon a record of eight years. Nearly all of the stations in the higher portions of the Sierra Nevada Mountains receive more than 100 inches of snow every winter. The greatest amount recorded during one winter is 73.7 feet, which fell at Tamarack during the winter of 1906-07. From 40 to 50 feet of snow has been known to accumulate on the ground at one time in the high Sierra Nevada. The importance of this snowfall has been pointed out by Professor R. DeC. Ward:

"The Sierra Nevada Mountains well deserve their name. To them California owes much, if not most, of her present prosperity and her promise for future growth and development. The many feet of winter snowfall which accumulate on the upper slopes mean millions upon millions of dollars each year to the farmers and fruit growers of southern California. Were all this precipitation to fall as rain, every winter would witness devastating floods, and every summer would wither and destroy the crops."[2]

WATER POWER: DEFINITION AND STATUS.

As may be surmised from the foregoing data, California has a water problem of great complexity. The foundation of it lies in the nature of the precipitation, i. e. its irregular distribution both in time and place. Irrigation, floods, city water supply, and water power are all intimately related subdivisions of the general water problem. It is with the last subdivision and its relations to the foregoing that we are here concerned.

Water power, when available in a sufficient amount, is the ideal form of energy, combining a constant supply with a minimum of cost. Wind power is sometimes referred to as an ideal form of energy; but, unlike water movement, air movement cannot be controlled artificially, for which reason wind power must always remain of secondary importance when compared with water power. Water acts as a motive power by its weight, by its pressure or impact, or in both ways. When the motive power is weight alone the device employed is frequently a water wheel like the antiquated mill wheels. When pressure or impact is involved the energy is made available by means of modern water wheels, turbines, or hydraulic pressure engines. In the modern hydraulic power plant the water is employed to operate turbines or water wheels which in turn drive electric dynamos, and the electrical energy thus derived is transmitted to and utilized at places far distant from the source of supply. This application of power is a recent development, the first commercial enterprise of the kind having been established less than twenty-five years ago. It is because of the possibilities seen in hydroelectric development that water power has assumed a new significance within recent years.

In order to justify its development and use, electric power generated by falling water must be cheaper than steam-driven power, since it is, generally speaking, less dependable than the latter. This is due to unavoidable interruptions in the service from lightning, breaks in transmission lines, low water, floods, or ice jams. The initial cost of installing a hydrolectric plant is much greater than that of a steam plant, since it requires the construction of reservoirs, generators, and transmission lines in remote and inaccessible places. However, when the installation is complete the cost

*From the *Journal of Geography*.

[1]See the sections on the Southern Pacific Province in R. DeC. Ward: Rainfall Types of the United States, *Geogr. Rev.*, Vol. 4, 1917, pp. 131-144 and in:

[2]R. DeC. Ward: Mean Annual Rainfall of the United States with notes on the new chart of average annual precipitations, *Monthly Weather Rev.*, July, 1917, pp. 338-345.

of maintenance is only a small fraction of that of a steam plant, since it requires no fuel and but little labor.

NATURAL CONTROLS OF WATER POWER.

There are five well-recognized factors which control the flow of streams and therefore determine the water power available at any time. With particular reference to conditions obtaining in California, these are as follows:

(1) *Climate.* For California the climatic features here involved and discussed at length in the introductory paragraphs may be summarized thus: deficient precipitation in the lowlands, abundant precipitation (mostly snow) in the mountains; nearly all of it occurring during the winter half-year, while the summer half-year is everywhere dry and hot with excessive evaporation and almost unbroken sunshine. All these features conspire to produce high water in the streams during the first six months of the year and low water during the latter six months.

(2) *Topography.* In contrast to much of the eastern United States the country west of the Missouri is characterized by physiographic immaturity. It is a region of marked topographic contrasts with swiftly-flowing streams of sharp gradient and correspondingly high potentialities for power development. The State of Washington, Oregon, and California alone are estimated to have 40 per cent of the developable water power of the country. Moreover the collection of water in natural or artificial reservoirs at considerable heights in such a region makes possible the development of power plants where the head or pressure is great.

(3) *Geology.* The permeability of the underlying rock is an important consideration. In the Sierra Nevada Mountains, where most of California's water power is to be found, the rocks are of great variety, but they are mostly hard granites, more or less impervious to water and not easily eroded.

(4) *Vegetation.* Whether or not the headwaters and drainage basin of a stream are forested determines in large measure the rate of run-off. Generally speaking, when the headwaters of a stream are densely forested the run-off is slow and steady; while, if the forest cover has been removed or the basin is naturally bare of vegetation, the run-off is sporadic, and destructive floods are frequent.

(5) *Artificial agencies.* Reservoirs, either in the form of natural lakes or artificial dams, naturally affect the flow of streams to a large extent. In California there are comparatively few natural lakes of large size along the streams. Artificial dams, however, are numerous and increasing in number from year to year.

HISTORY OF HYDROELECTRIC DEVELOPMENT IN CALIFORNIA.

The great modern developments of industrial power have been those connected with electricity and oil, and, while California is remote from commercial coal supplies, in both of these new sources of power the State ranks high. About 70 per cent. of the power used comes from fuel oil and natural gas, and about 20 per cent. from water power. But the oil output will soon have attained its maximum and will begin to decline, and the total power requirements increase from 10 to 15 per cent. per annum.

The State of New York, largely because Niagara Falls is situated on its border, leads the Union in developed water power. California is second, exceeding in this respect the State of Washington, which has however a larger amount of developable power. Practically all of the water power is of the hydroelectric type, in the development of which California claims the honor of being a pioneer.

The first hydroelectric plants in California were primarily experiments, and the energy was used locally to operate mills and mining machinery. The first commercial hydroelectric high-tension transmission in the State was the plant erected in the town of Folsom in 1895. It supplied the city of Sacramento. Since that time development has been rapid. Today 19 power companies operate 80 plants, producing nearly 700,000 horse power and supplying electrical power to 596 cities and towns.

The progress of electrochemistry and the rapid industrial development of California explain in a measure the rapidly increasing use of hydroelectric power. While agriculture has long been the leading occupation in the State and perhaps will remain the leading one for some time to come, manufacturing is increasing at a more rapid rate than is agriculture. According to the California Development Board the value of California manufactures has increased from $67,000,000 in 1870 to $750,000,000 in 1917.

WATER POWER IN RELATION TO IRRIGATION.

Successful agriculture requires that the land shall receive a minimum of 18 inches of water per year. As is indicated on the map, a large part of California—including most of the southern part of the State, all of the San Joaquin Valley, much of the Sacramento Valley, and a portion of the northeastern plateau region—have an average annual precipitation of less than that amount. By means of artificial irrigation, however, much of this land has been reclaimed, and as a result California ranks high in agriculture, particularly in horticulture. The latest figures available, the Census of 1910, show that 39,352 (44.6 per cent.) of the 88,197 farms were irrigated. The area irrigated was about 2,664,000 acres. In the 1916 report of the California State Board of Agriculture it is stated that 84 per cent. of the irrigation water used in the State came from streams, 13.2 per cent. from pumped wells, and only 0.6 per cent. from artificial reservoirs.

Water power and irrigation are intimately related phases of the larger water problem, and neither can be discussed without a reference to the other. In water power development little or no water is consumed, as it is in irrigation. The power plants simply extract the potential energy of the water as it descends and make no further use of it after it has passed the water wheels or turbines. The power plants are situated in the mountains while the agricultural fields are in the lowlands and foothills. Hence it would appear that there should be no conflict in water rights. There has been, however, an unfortunate antagonism between users of irrigation water and power interests, an antagonism which to some extent has delayed water power development. The ranchmen desire the water to come down from the mountains in large quantities during the dry season, while the power plants can use it only at a regular rate, more or less constant throughout the year. But the situation, due in considerable part to a misunderstanding and to a lack of information, is not hopeless. At the present time there are needed greater recognition on the part of the power interests of the water rights of the ranchmen and better knowledge among the latter as to the methods of modern hydroelectric development and the benefit to be derived from it. Mountain reservoirs can serve the double purpose of irrigation and power sources. The State Water Commission and the State Railroad Commission are rendering valuable service in attempting to harmonize the conflicting elements.

One of California's beautiful natural power sites—Vernal Falls, Yosemite National Park, with a drop of 400 feet

WATER POWER IN RELATION TO FLOOD CONTROL.

Though much of the lowland of California has deficient precipitation, it is nevertheless subject to destructive floods. Notable floods occurred along the Sacramento and San Joaquin Rivers in 1907, 1909, and 1911, in the vicinity of Los Angeles in 1914, and in the vicinity of San Diego in 1916. The first named floods were due primarily to warm spells in midwinter, with rain falling in the Sierra Nevada while the ground was deeply covered with snow. The last-named flood was due primarily to excessively heavy rainfall throughout southern California. When it is remembered that most of the heavy precipitation comes within a period of six months and sometimes within a shorter period, the cause of floods can readily be understood; and when monthly and daily excesses of precipitation like those mentioned in the introductory paragraphs of this article occur, it is evident that floods also contribute another factor to the California water problem.

Basing his conclusion upon investigations made by the U. S. Geological Survey, Mr. M. O. Leighton states that 55 to 60 per cent. of the flood waters of the country can be saved by the utilization of maximum storage capacity.[3] Although the cost of such construction would be enormous in the aggregate, the saving that would accrue in relief from flood damages would soon return the entire investment. In by far the larger proportion of the river basins such a saving of flood waters would insure practically entire relief from flood damages. The construction of reservoirs necessary to prevent floods would, under proper management, involve an increase in the water power possibilities of the United States equal to about 60 million horse power.

CITY WATER SUPPLY.

When cities are small their water needs can easily be satisfied; but when they attain the size of San Francisco or Los Angeles the domestic water supply becomes a matter of considerable importance and involves heavy expenditure. The development of the water supply in each of these cities merits attention.

At the present time San Francisco is constructing at an enormous cost an aqueduct from the Hetch Hetchy district which is designed to deliver by force of gravity a quantity of water somewhat in excess of 400 million gallons daily—under extreme conditions 500 million gallons. When completed the aqueduct from the intake to the center of San Francisco will be 189 miles long. When construction was begun, in 1912, the city did not propose in the immediate future to build any plant for the development of hydroelectric power. Power development was considered subordinate to domestic water supply. But the city planned carefully to conserve all reasonable opportunities for power development against the time when it would become expedient to use them.

Though at this present moment the aqueduct is not complete, the power is already needed. About one-half of the electric street railway lines in San Francisco are municipally owned, and plans are under way for the purchase of the remaining privately owned lines. Furthermore, a street electric lighting system is at present being installed which, when completed, will be one of the most efficient in the United States. Municipal needs for electric power have become almost as urgent as domestic water needs. In view of these conditions, a 4,000 horse power hydroelectric plant was installed on the Hetch Hetchy aqueduct and is already in operation. It is estimated that in three years San Francisco will have surplus power for sale and that the receipts from this source will practically pay interest on the cost of the mountain development of the system.

A few years ago Los Angeles, the metropolis of southern California, recognized that its future growth was dependent upon an adequate water supply. At huge cost an aqueduct 259 miles in length was constructed to reservoirs in the Owens Valley, near the eastern base of Mount Whitney. In its construction also power development was a subordinate consideration, though provision was made for future utilization when the demand should justify the installation of power plants. In 1917 there were three hydroelectric power plants in operation along the Los Angeles aqueduct, and these

(*Concluded on page* 271.)

[3]Papers on the Conservation of Water Resources, *U. S. Geol. Survey Water Supply Paper*, 234, Washington, D. C., 1909, p. 27.

"Flying Sickness"*

A Discussion of Its Cause and the Best Means of Combatting It

By Lieut.-Col. Martin Flack, R.A.F.M.S.

From time to time articles on so-called "flying sickness" have appeared in various periodicals. In some of these the suggestion has been made that the airman is subject to a special disease, somewhat akin to that of the diver or the worker in compressed air. This is not the case. The cause of "diver's palsy," "caisson disease," or "compressed air illness" is now thoroughly well established. When man is subjected to an increased air pressure he dissolves in the fluid portion of his blood a considerable amount of nitrogen from the surrounding air. When the air pressure is diminished this nitrogen is again given off. If the diminution in pressure be rapid, then bubbles of gas are liberated inside the blood vessels, in the same way as bubbles of gas are liberated when fluid is removed from a syphon of aerated water. These bubbles then circulate in the blood and produce symptoms, which vary according to the part of the body in which they become lodged—if in the muscles and joints, then the familiar "bends" are produced; if in the nervous system, then paralysis may ensue; or if in the blood vessels of the heart or brain almost instantaneous death may follow.

The great protection, therefore, against caisson disease or diver's palsy is in the gradual and not sudden diminution of pressure, so that bubble formation is prevented. It is for this reason that workers in compressed air are now always detained for a relatively long period of time in an air lock before emerging from their work. At first sight, therefore, it might be supposed that an airman making a rapid ascent, and, in other words, subjecting himself fairly rapidly to a diminution of the surrounding air pressure, might be liable to symptoms arising from the same cause as does diver's palsy. This, however, is not the case, since the diminution in pressure is not sufficiently great or rapid to bring about any liberation of gases held in the watery portion of the blood. In diver's palsy and caisson disease one is dealing with a reduction of pressure of from two to five atmospheres, whereas in flying one is generally dealing at the most with a diminution of pressure of a little more than half an atmosphere, and certainly always less than one atmosphere, which is easily within the margin of safety for the rate of decompression in compressed air work.

The idea, therefore, that airmen are subject to any special "flying sickness" of this nature may be dismissed. Actually a diminution of pressure produces little or no effect upon the human body, since the body may be regarded as being more or less of a fluid nature. Roughly speaking, body tissues contain 70 per cent. of fluid, and alteration in the external pressure is transmitted equally to all parts of the body, so that no effects due to pressure arise actually within it.

Such pressure effects as are produced are due to the action of diminished pressure upon gases which are, so to speak, enclosed by the body. In particular is this the case with regard to the gases pent up within the air spaces of the nose, and particularly in the air channel (the Eustachian tube) connecting the back of the throat to the middle ear. The alteration in pressure in the air spaces connected with the nose causes many airmen to complain of discomfort, particularly in the brows, due to a distension of the air within the frontal air sinuses, which lie in that region.

In regard to the Eustachian tubes, trouble may ensue from the fact that it is difficult to obtain equalisation of pressure with that of the surrounding atmosphere, and therefore unpleasant symptoms, such as noises in the ears, giddiness, and even severe pain, may ensue. To explain this in more detail it should be borne in mind that the passage to the ear drum by the external ear opening is relatively large, whereas the passage from the throat to the other side of the ear drum by the Eustachian tube is correspondingly small, and is really only patent during special acts, such as swallowing, which normally allows the atmospheric pressure on each side of the drum to be equalized. If, therefore, the atmospheric pressure is reduced, and the Eustachian tube remains closed during an ascent, then it is possible for there to be, say, at 18,000 feet, a pressure of approximately 15 inches of mercury on the outside of the drum, with a normal pressure of 30 inches of mercury on the inside of the drum, the result being that the drum is pressed tensely outwards, causing pain, discomfort, deafness, or giddiness. Normally, however, during ascent such air would escape from the openings of the Eustachian tubes, through the orifices at the back of the throat, and pressure is thereby equalized.

It is during descents rather than during ascents that trouble may arise in regard to the effects of pressure on the ear apparatus, unless steps are taken by the pilot to equalize the pressures on either side of the ear drums. For this reason airmen, often from their own experience, now almost universally practise the act of forced swallowing during descents. If a descent be very sudden the pressure within the tubes is in many people best equalized by gently inflating the ears, namely, by pinching the nostrils, closing the lips tightly, and then gently forcing the air out of the chest into the nose and ears until a clicking sound is heard in both ears. Such inflation should be gentle and should be practised, generally speaking, once for every 1,000 feet of drop.

If for any reason an airman finds difficulty in equalizing pressure in his ears, or can equalize the pressure easily in one ear only, and therefore experiences pain or giddiness during flying, it is well for him to consult his medical officer. Generally speaking, the flying officer should remember that any catarrhal condition of the nose and throat, such as that which may arise from colds and excessive smoking, may lead to blocking of the Eustachian tube, and for this reason the flying officer should, as far as possible, take pains to keep his throat and nose in as healthy a condition as possible.

If not directly due to the effects of diminished pressure, to what, then, is "flying sickness" due? In reality it would be better to abolish the term "flying sickness" and to employ instead some such term as flying stress or strain. Flying strain is due to the repeated exposure of the airman to diminished oxygen tension, and partakes of the nature of fatigue. With every ascent, especially to high altitudes, a strain is thrown upon the nervous, respiratory, and circulatory systems of the body, owing especially to the fact that these are called upon to function in an atmosphere in which the oxygen tension is diminished. After a time, therefore, it is found that these systems are functioning less efficiently, owing to the oft repeated strain, and it is well then for the aviator to take a rest from flying, or at least to cut down the amount of work done in the air, especially that done at high altitudes.

From the examination of successful aviators it has been possible to devise a number of tests which will show how the aviator is wearing. It is every bit as important for a medical officer to be able to overhaul the human engine and say whether it is fit to take the air as it is for the technical officer to be able to say whether the machine itself is in condition to be taken into the air. It is for this reason that much work has been expended upon the examination of the successful flying officer in order to devise tests which indicate the fitness or otherwise of the individual.

With the onset of commercial aviation tests such as these will assume perhaps even an added importance, since it will be particularly desirable that no pilot shall be subject to any breakdown which will endanger the lives of those passengers entrusted to his care. For this reason in the future it will be necessary for pilots to be "vetted" from time to time and thoroughly overhauled from the point of view of flying strain.

With adequate medical supervision no pilot should in the future be permitted to reach such a stage of flying strain that he has to cease from flying altogether. To prevent the onset of flying stress the pilot should more or less keep himself in training by leading, as far as possible, a healthy outdoor life with vigorous games.

From the medical point of view the great preventive of flying stress is the use of oxygen, which has proved of incalculable benefit to the Service. It is generally supposed that oxygen is required only for altitude flying, but this is in reality not the case. It is true that the effects of lack of oxygen are more marked at high altitudes, and that the gross symptoms of distress are abolished by its use, so that the mental alertness and the quickness of the reflex movements of the pilot are retained in a remarkable degree. This is all important. To take a single example—the time of visual appreciation without oxygen is on an average 25 per cent. slower at 18,000 feet. If therefore in aerial warfare a man with oxygen meets a man without oxygen at this height the man with oxygen will get in his shot before the man without oxygen.

It has been shown, however, that for flights, especially of long duration, at relatively low altitudes (5,000 feet or even less) considerable fatigue is entailed, which is often, however, not appreciated by the pilot, but can be proved with absolute accuracy by the use of scientific instruments.

It may therefore be possible, and certainly advisable, for pilots of even low flying machines to use oxygen during a long flight, in order to mitigate the after effects. This will become quite practicable with the development of the use of liquid oxygen, which has the advantage of being much lighter to carry than the compressed gas. For flights of shorter duration, however, compressed oxygen will still prove very serviceable, especially on account of the greater facilities it affords in the matter of storage.

It is often found that there is a prejudice against oxygen, which is believed by many to be a "dope." This misconception cannot be too strongly repudiated. Most of us can remember the familiar experiments of our schooldays, in which we were shown a glowing match bursting into flame in the presence of oxygen. Many people, therefore, believe that the human body itself burns at a quicker rate when given an extra oxygen supply. Practical experiments with accurate measurements have proved that this is not so. When extra oxygen is supplied to the body at ground level only a small amount is taken up into the body by the lungs, most of the excess being breathed out again into the air. During flights, however, the aim of giving oxygen is to do away with the deficit at altitudes, and not to give more oxygen than would be available to the individual at ground level.

In fact, from an engineering point of view it is not feasible to give an excess of oxygen to the pilot, since the weight entailed in carrying large amounts of compressed oxygen would add greatly to the weight of the machine, and would therefore be ruled out on this account. It has to be emphasized therefore that oxygen is administered to aviators to bring the pressure of oxygen contained in the lungs at altitudes up to that prevailing at ground level, thereby rendering the circulation and respiration more efficient, and the nervous system more alert.

There is no danger of the pilot who takes oxygen developing an "oxygen habit," since oxygen is in no sense a drug.

When breathed, oxygen is best taken from a mask, and preferably continuously, since thereby the intermittent strain to which the organism would otherwise be exposed is avoided, and the airman maintained in the best of condition.

Tobacco and alcohol also have an important bearing upon the question of flying strain. Excessive smoking of cigarettes, especially the inhaling of smoke, produces shortness of breath and a quickening of the heart beat. Since anything which interferes with the breathing is particularly harmful to the flying man, there is little occasion to labor this point. With excessive smoking also the quickness of vision may be impaired.

In regard to alcohol, it is to be borne in mind that, although an aviator may experience a desire for a so-called "stimulant" after a fatiguing flight, the effect of alcohol is evanescent, and too frequently one drink begets a desire for another.

All experimental work on the effects of alcohol upon the human body tends to show that from the point of view of efficiency the so-called beneficial effects are entirely illusory. By alcohol the judgment is affected, the "reaction times" slowed, and the fine coordination of muscular movement impaired. The importance of this to the aviator is apparent. To avoid disaster he must always be on the alert and ready at the shortest notice to translate into the necessary action any message which reaches his brain. In particular is "steady drinking" of a degree insufficient to produce intoxication inimical to efficient aviation. Furthermore, the idea of "priming up" the system by alcohol before a flight is wholly pernicious and strongly to be condemned. Such a course, even when indulged in with apparent success, cannot, if habitually persisted in, end otherwise than in disaster.

*From *Aeronautics*.

"All Wool and a Yard Wide"

Anybody can measure a piece of cloth with a stick and tell whether it is a yard wide or not. Anybody can tell whether it is all wool or not by boiling out a little piece in a test-tube with a solution of caustic soda over an alcohol lamp. Whatever does not dissolve is not wool. One test is as easy as the other. The trouble is we haven't the chemical habit as yet. The public wields the stick, but neglects the test-tube.—*Little Journal.*

Photographic Permanence*

The Distinction Between the Print That Lasts and the Print That Does Not

By C. Welborne Piper

In these days when processes which yield prints of unquestioned permanence such as carbon and platinum form only a small proportion of the immense output of photographs of various kinds, and when also many different methods of toning prints by other processes are adopted the question of permanency is one which has an interest for every photographer, and is, moreover, one of which a photographer who sells his work needs to have some fairly comprehensive knowledge. It may therefore be of interest to review the question from the point of view not only of making prints of the utmost permanence, but also from that of satisfying customers as to the quality of prints in this respect. In this inquiry it is desirable at the start to obtain some more adequate definition of permanence than its dictionary meaning of "continuance in the same state or without any change which destroys form or character." The dictionary definition does not help us very much. Another which has been proposed is that a permanent photograph is one the image on which will last as long as the paper which supports it. This again is a definition which is incomplete unless certain conditions under which the print is kept are specified. Moreover, it is one which marks too high a standard of permanence. Paper, if of the reasonably good quality which is used for the preparation of photographic printing materials, may reasonably be relied upon to last for a very long term of years. In the case of paper of such high quality as is employed in the making of platinum prints its period of life may be of the order of hundreds of years, and would thus make great demands on the stability of the image. True, a black platinum print possesses an image which is so unalterable that it rivals its paper support in permanence, and justifies the remark of Mr. Chapman Jones (in "Photography of To-Day," p. 196) that "there seems every reason to suppose that if platinum prints had been made in Abraham's time, or when Egypt was at the height of its glory, they might, if preserved with reasonable care, have been available for our information at the present day." Unfortunately such considerations as these will lead us nowhere in the direction of providing a definition of permanence in photographs such as can be adopted for practical purposes under present-day conditions. We think that such a definition is to be found only in some formula representing what the public considers permanence. Opinions will differ, but such a formula is that no marked alteration will be observable in prints, when kept under reasonable conditions, within a period of, say, twenty years. We are now speaking of prints belonging to the vast majority which are bought and sold as portraits, views, etc. Obviously twenty years would be much too short a time for prints in which permanence is a prime desideratum; such prints would be expected to last for fifty or a hundred years. Whatever may be thought of such a definition it provides a useful basis from which to explore printing processes in regard to permanence, and to bring together facts of interest to amateur photographers and of service to professionals in dealing with their customers.

A point which requires first to be touched on is that of what may be termed "permanent" photographic processes, as this phrase is (or was) understood in ordinary speech. In regard to this it may be said that up to within ten or fifteen years ago a photograph by a "permanent process" meant one by either the platinum or carbon process. There is a very good reason why it had this signification, for during the twenty-five or thirty years during which albumenised paper was the printing method in universal use, carbon and platinum prints were the only two forms of photograph which could be said to have established themselves in the esteem of the public as yielding prints of unquestioned permanence, and in this respect were distinguished from the ordinary silver prints with their liability, particularly in later years, to fade. Thus up till about ten years ago it could reasonably be said that in the County Court sense a permanent print was one in platinum or carbon. And it would then have been easy for the party to a legal dispute to show that such was the general interpretation of the term in the trade. The advent of bromide and other printing papers has done a good deal to disturb that position, and it is very doubtful whether the term "permanent photograph" now has this same significance.

Coming now to some notes on the degrees of permanence in photographic prints, it is important to draw distinctions between them, not on the basis of single specimens which have been proved to have lasted for such and such a number of years, but on one which expresses what is the quality of permanence of the great bulk of prints produced by a given process. There is a sharp distinction between the two. It would be easy to claim exceptional permanence for, say, printout silver prints on the strength of one or two which remained fresh and good after twenty years. But the essential difference between the admittedly "permanent" processes (carbon and platinum) is that with them it is a matter of difficulty, almost of impossibility, to make prints which are not permanent, whereas in the case of almost all other printing processes the degree of permanence is largely conditioned by the care and experience exercised in working the processes, and thus the real quality of a process as regards permanence must be judged on general experience of the results obtained with it, and not by single examples which may be the result of care and skill which the process would not receive under ordinary commercial conditions.

Leaving now carbon and platinum out of consideration, there can be no doubt that the most permanent form of photograph among the papers available at the present time is that on a bromide or gaslight paper. Such a print, if properly made and mounted and preserved under suitable conditions, should amply fulfil such a requirement, as regards permanence, of twenty years' life. The effect of time upon it, when it is mounted and framed, should never be more than a slight yellowing of the whites, and need not necessarily be that. By exposure to the products of combustion from gas or stoves such prints are liable to exhibit, in the course of time, a bronzed or semi-metallic deposit, chiefly in the shadows, which is a certain disfigurement, but not one which could be reasonably called impermanence. The same effect is to be noticed when prints on these papers remain in contact with ordinary printing paper as they do when inserted in books. Such action appears to be due to matter in the paper with which the photograph is in contact, and plenty of evidence as to the regularity of the effect is to be found in the prints which formerly, from about the year 1887, were inserted in the "B. J. Almanac." In some cases this bronzing or solarization has reached a point at which it is a marked disfigurement; in other cases it is accompanied by pronounced yellowing of the whites.

A sulphide-toned bromide, however, is less liable to this bronzing, and for the very plain reason that the bronzing is a species of slow sulphiding, and, if the sulphiding process is carried out thoroughly when toning, there cannot be the opportunity for its often irregular appearance in process of time. In this respect undoubtedly sepia prints made by the bleach and sulphide process are superior to those yielded by hypo-alum and similar toning processes in which the sulphiding action is not carried to a point of completion. Generally speaking, sepia bromides, by either process, may be considered as of a higher degree of permanence than the untreated black-and-white prints. We do not think that the same can be said of the warm-toned prints which of late years have come rather more into use and are produced by treating the sulphide-toned prints with a gold toning bath. Attractive as these effects are, we think there is evidence to show that they are somewhat susceptible to change by exposure to light. The change is small—some years ago we found that some months' constant exposure to ordinary daylight was necessary to produce a distinct change—but the liability does certainly exist. Of other toning processes which, before the sulphide method became popular, were largely employed, it is not possible to speak in the same terms as of sulphide-toning. Prints toned with copper or uranium are exceedingly liable to exhibit, in the course of a year or two and often sooner, bronzing and other disfigurements which are of a degree such that the purchaser of a print would quite reasonably object to. Our experience of prints toned with Schlippe's salt is small, not enough to justify us in expressing a positive opinion; our inclination is to place them in a category somewhere between those sulphide-toned and those treated by one or other of the processes just mentioned.

Coming to what are sometimes called even nowadays "silver" prints, those on ordinary P.O.P. require to be placed in a lower class as regards permanence than black-and-white bromides. They are appropriately so classed when toned by the best method, namely, the use of a separate gold bath followed by fixing. Although in theory the use of a combined toning and fixing bath should yield prints which are just as permanent as those separately toned and fixed, there can be no doubt that P.O.P. prints by the combined method rightly rank still a little lower. In regard to those toned with platinum, a process which deservedly has now largely gone out of use, the results were often of a very low degree of permanence indeed; apparently the use of any platinum toning bath on a gelatine paper yields results which cannot be depended upon for permanence. The other variety of silver printing paper, viz., self-toning, may, we think, be broadly classed, without injustice to it, with the results obtained on ordinary P.O.P. by the combined bath. Here experience is somewhat conflicting; probably for the reason that self-toning papers, being chiefly used by amateurs, are not always handled under the best conditions for working which papers secure in professional establishments. Still, we think that general experience is to the effect that their permanence is a little inferior to that of P.O.P. toned in the separate bath. A distinction must also be drawn between gelatine and collodion self-toning papers; there seems no doubt that those of the latter class are superior to those of the former in stability. Of the remaining type of silver printing paper, namely, collodio-chloride or C.C., there is greater divergence in the matter of permanence than in the case of perhaps any other paper. The impermanence in this case takes the form not usually of general fading or yellowing, but that of the appearance of spots often within a very short time of the prints having been made. Worked under the best conditions and with the fullest knowledge of the precautions which are needed in its manipulation, C.C. paper is no doubt capable of yielding prints which are the equal, if not the superior, of those on ordinary P.O.P. toned by the separate bath. But in less skilled hands its results have often proved to be positively fugitive, a chief cause no doubt being the necessity of removing all traces of the acid platinum toning bath before the prints are passed on to fixing.

In concluding these notes we should revert for a moment to the platinum printing process of which we have spoken above as though its results were invariably of the very highest degree of permanence. An exception to this general statement needs to be mentioned. While nothing in the way of a photographic image is more permanent than that of a black platinum print, the same cannot be said of all platinum prints of sepia color. Methods of introducing a greater or less degree of warmth by additions of mercury, etc., to the developing bath when using the black paper almost all of them represent a sacrifice of undoubted permanence to pleasing appearance. Also, we think it may be accepted as true that for really permanent sepia results on the papers especially manufactured for this effect hot development is an essential factor. Such is the method adopted for the sepia paper of the Platinotype Company, and both chemical tests and those of time fully prove that the results are permanent. Equally we have in our possession plenty of examples of sepia platinum prints in the making of which the method adopted has been that of cold development on papers manufactured for use according to this system; they show the pronounced fading which is the result of ordinary exposure in moderately lighted rooms over a period of years which is not more than ten at the outside. Palladiotype prints, recently come into use as the result of the restriction on platinum, presumably are just as permanent as those by the ordinary platinum process. This is only an inference from the known properties of palladium metal, but it is no doubt one which experience, as time goes on, of palladiotype prints will confirm. We have not referred to oil or Bromoil prints or those transfer effects obtained by taking impressions from these latter. Obviously such prints possess exactly the permanence of the inks which are used for pigmenting. There is no reason whatever why these inks should not be fully permanent, and therefore such prints, both from the nature of the pigment which forms the image and from that of the medium which hold it, deserve to rank as fully the equal as regards permanence of those by any process.

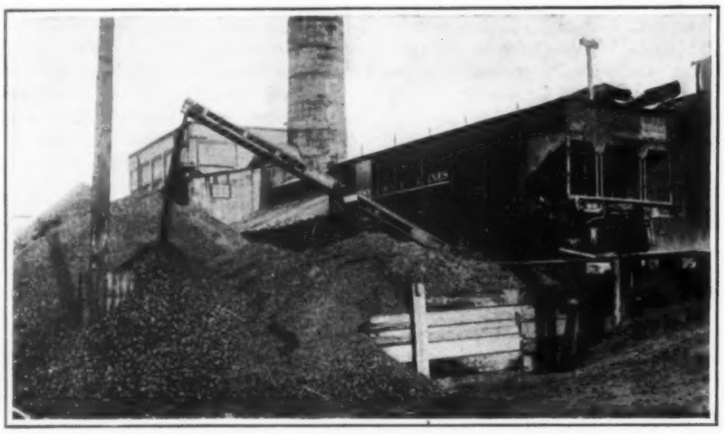
*From *British Journal of Photography*.

The Portable Scoop Conveyor

The Present Last Word in the Transfer of Bulk Materials

It is almost a truism nowadays to remark that, in order to secure economical operation and maximum efficiency in handling bulk materials, labor must be supplanted by machinery. It is indeed an old story that the man with the wheelbarrow has been supplanted, in large operations like the loading of ships with ore and similar cargoes, by the machine that handles tons of material continuously, with giant scoop and belt conveyor. But the adaptation of these instrumentalities to small-scale tasks is not always a simple matter, and it is not always obvious, even, that it can be done at all.

Still, the man with the shovel and the wheelbarrow is expensive, and industry, be it small or large, will prosper in proportion with the extent to which it does away with him. Even the old style fixed conveyors required a deal of hand labor in shoveling the material up into the receiving hoppers, a circumstance which greatly limited the advantage to be derived from their installation.



Unloading from coal car to storage pile with a scoop conveyor

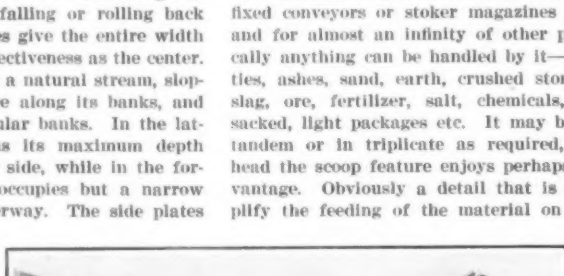
A new style of portable conveyor for small-scale work, which cuts in half the labor of feeding its big brother, and does many small jobs to which its big brother will not stoop, is shown in the accompanying illustrations. The distinctive feature of this machine, and the one which gives it the name of "scoop conveyor," is the scoop on the feeding end. This scoop can be pushed into the material to be conveyed, even to the point of actually burying it therein, if necessary. This makes it possible simply to scrape the material to be carried on to the belt, instead of lifting it by shovelfuls or barrowfuls into the feeding hopper. This feature, combined with the portable conveyor idea, which is not in itself any longer a novelty, insures that however short be the distance through which material has to be transferred from one conveyor to another, from resting place to conveyor, etc., there will be a machine to do it, and the man with the wheelbarrow and the hand scoop will not have to waste his time and his employer's money doing the work by primitive methods.

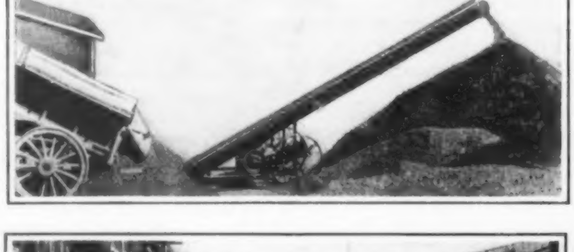
Another valuable feature of the conveyors illustrated lies in the structure of the conveyor sides, or skirt plates, as they are called. These form a trough which makes it possible for a belt of only twelve inches width to equal the carrying capacity of an ordinary twenty-inch belt. On the ordinary or troughed belt, the material is carried in the main in the trough at the center, that on the sides falling or rolling back into the trough. The side plates give the entire width of the belt the same carrying effectiveness as the center. It is just the difference between a natural stream, sloping up gradually to the surface along its banks, and a cut canal, with its perpendicular banks. In the latter case, the stream maintains its maximum depth right up to the bank on either side, while in the former instance the deep water occupies but a narrow strip in the center of the waterway. The side plates also give an increase in the height to which a conveyor of given length can be made to carry material.

It is more or less of an old story to point out that the use of a properly designed conveyor not only saves direct labor charges, but results in a speeding up of the work itself. Two men with a conveyor will do the work of from four to twelve men, depending upon conditions; and in addition, there is the advantage that a given truck will be loaded in from one-quarter to one-sixth the time required by shovellers. So the driver of the truck spends less time waiting for his load and the truck earns its upkeep better and pays a better profit. It is the same idea that makes it possible to use a motor truck as a locomotive exclusively, hauling trailers which carry the load while the truck itself goes unloaded and saves money for its owner because of the vastly greater number of trips that it can make in a given time. Still another item of no mean value is the fact that the available storage space is increased by enabling the workmen to pile higher in a given shed or yard.

The carrying capacity of the twelve-inch scoop conveyor, based on handling coal, is one ton per minute, provided the supply of material at the receiving end of the machine can be kept up to this rate. If the storage pile is of sufficient height, one man can easily approach this maximum to the extent of feeding one-ton in a minute and a half, otherwise he may require from two to four minutes. Where speed is the prime consideration it can be attained by assigning two men to the work of loading the conveyor. In delivering loads from hopper-bottom cars to trucks, there is no question of the supply of material at the feeding end of the conveyor, and the extreme speed of one ton per minute can be maintained without difficulty with one man to attend to the loading end of the apparatus.

Perhaps it will not be superfluous to point out explicitly that the leading role of the scoop conveyor is in the storing, reclaiming and loading of bulk materials and light articles. It is the machine *par excellence* for transferring and transshipment. No limit can be set to the different applications which may be made of the machine; it is available for elevating material to tanks or platforms in chemical and industrial works, for feeding from cars and delivery from or into fixed conveyors or stoker magazines at power plants, and for almost an infinity of other purposes. Practically anything can be handled by it—coal of all varieties, ashes, sand, earth, crushed stone, blast furnace slag, ore, fertilizer, salt, chemicals, grain loose or sacked, light packages etc. It may be used singly, in tandem or in triplicate as required, and under this head the scoop feature enjoys perhaps its greatest advantage. Obviously a detail that is designed to simplify the feeding of the material on to the conveyor multiplies its utility by the number of conveyors on to which it is necessary to feed the material before it reaches its final destination; so with the scoop conveyor we can do things that would not be practical without it. Indeed, it would seem that there is hardly any limit to the height to which storage piles may be raised, if the material is brought to them and taken from them in this fashion.





Unloading and loading wagons with the portable scoop conveyor, and using three conveyors to unload from cars to a giant storage pile

An Apparatus for Growing Crystals Under Control

By J. C. Hostetter

Crystals, to be suitable for the study of the effects of pressure, must be perfectly developed and of comparatively large size. The criterion of perfect development, in this case, is not in the possession by the crystals of those rare faces that so delight the crystallographer, but in the possession of maximum strength. In general, it may be said that the causes which diminish the transparency of those crystals that are normally transparent, also decrease the strength of the crystals. Perfect transparency in a crystal results only when the rate of growth is small and constant, or nearly so, throughout the entire growing period. Nontransparency in a crystal (except that due to the inclusion of foreign solids), is usually indicative of suddenly increased growth rate with the attendant development of cleavage planes and, frequently, inclusion of mother-liquor. For growing crystals that are suitable for pressure studies there is required, therefore, apparatus in which *all* variables affecting rate of growth are under control. While there are certain important exceptions which cannot be adequately explained at the present time, in general the degree of supersaturation in the mother-liquor at any time determines the increment of growth, consequently, the conditions affecting supersaturation—primarily, temperature and evaporation—must be under definite control. Of lesser importance—but nevertheless, essential—are the direction of concentration currents, and the number of crystals which serve as nuclei for growth. When these variables are controlled it is not a difficult task to grow very perfect crystals of large size.

In this note we will confine ourselves to the growth of soluble substances from solution, and merely mention the growth of very slightly soluble substances in crystal form, which has been developed very thoroughly, and the growth of crystals from melts.

Neglecting the effects of hydrostatic pressure, it may be said in general that there are four methods of producing supersaturation in a saturated solution and, hence, growth of a crystal immersed therein. In a solution saturated with respect to a certain crystal phase at a definite temperature we may produce supersaturation by (1) lowering (or, in rare cases, raising), the temperature, (2) allowing the solution to evaporate, (3) dissolving in this solution held at constant temperature, extremely finely divided particles of the crystalline phase, or (4) adding another solvent in slight amount, as alcohol to an aqueous solution of a sulfate. It is quite evident that a crystal-growing apparatus based on any, or a combination of all, of these principles will be satisfactory if the variables are properly controlled, but in most of the crystal-growing devices described in the literature, the governing of some of the essential conditions has been left entirely to chance. Practically, devices based on temperature change are easier to control and, probably, the most easily constructed. The aparatus finally developed and described below is based on this principle.

To the essential conditions previously discussed we must

add another if the crystal-growing process is to be continuous; namely, that the supersaturated solution must be given definite circulation over the nuclei to be developed. Recently a crystal-growing apparatus with controlled circulation has been patented in Germany by Krüger and Finke. In this apparatus the mother-liquor is saturated in one chamber and then passed into another chamber of lower temperature where deposition takes place on the crystal nuclei to be grown; the solution is then returned to the saturating vessel. This patent of Krüger and Finke furnished the basis for the apparatus described by Valeton and the apparatus described below has been taken in part from that described by these investigators, but with numerous changes in details of construction.

Essentially the apparatus consists of 2 thermostats (S and C in figures 1 and 2), connected by tubes, with the necessary stirring and circulating devices. The thermostats are filled with saturated solution of the crystals being studied. One thermostat—the "saturator" (S)—contains the crystals, which maintain the solution saturated; the other thermostat—the "crystallizer" (C)—is held at a slightly lower temperature and it is in this cell that growth takes place. The thermostat vessels are storage battery jars, 20 by 20 by 20 cm., with 25 mm. holes drilled through the sides where necessary for the entrance of tubes. The thermoregulators (shown at T and T_1) are filled with mercury, and operate, through relays, the 5-candle-power cylindrical carbon lamps (H and H_1) used as heaters. In the saturator the cooled solution stream flows over a heater (H) before striking any crystals. The stirrers are of silver. A coil of small lead pipe (W) serves as a water jacket for one of the tubes connecting the thermostats. The openings (O and O_1) permit the removal of volunteer crystals, in case of accident, without disconnecting the entire apparatus; for a similar reason the return tube is cut at (R) and the platinum gauze filter (F) may be detached. The entire apparatus is packed with felt in a large, wooden box.

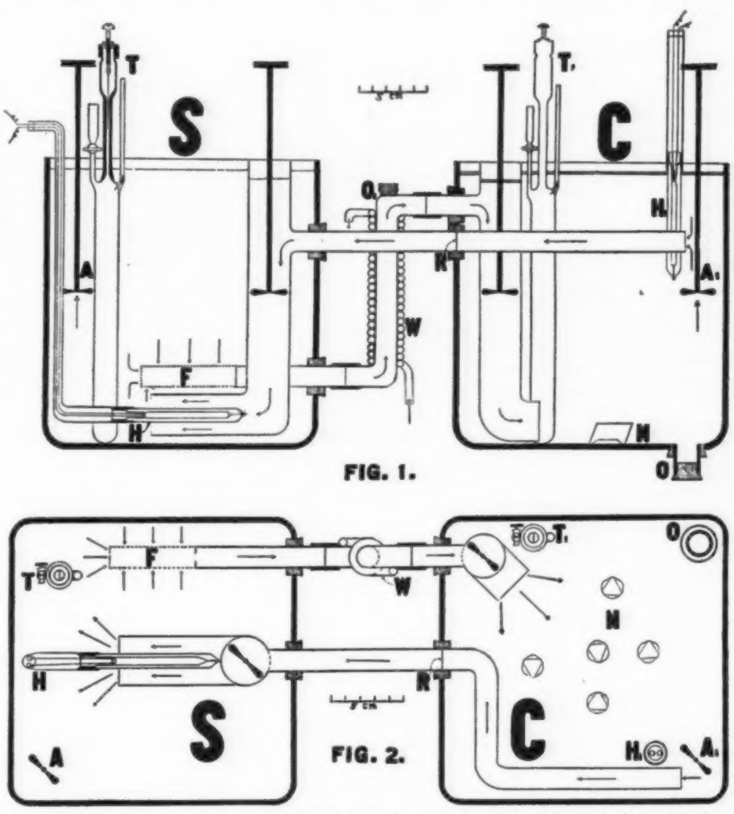
The degree of supersaturation of the solution entering the crystallizer may be controlled by adjusting (1) the temperature difference between the saturator and the crystallizer, (2) the rate of circulation between the two thermostats, and (3) the temperature and the rate of flow of the cooling water in the coils at (W). The difference in temperature between the saturator and the crystallizer that is permissible depends upon the change of solubility with temperature, and especially upon the extent to which the solution of a particular salt can be supersaturated. In the case of the alums, for instance, solutions containing salt equivalent to 15 per cent. supersaturation may be handled without causing precipitation, but on the other hand the change of solubility with temperature is fairly large. Practically, therefore, a temperature difference of 0.3° to 0.5° was found to give good growth.

With other materials, however, this difference might be too large and if so there would result a period of excessive growth, or a shower of volunteer crystals that would ruin the crystals being developed. No measurement of the actual rate of transfer of solution from one thermostat to the other was made. The rate of stirring must obviously be kept constant while crystals are being grown. If the room in which the apparatus is placed is subjected to large temperature fluctuations it is necessary to maintain the temperature of the water in the cooling coils at the same temperature as that of the crystallizer.

The course of the circulating solution is as follows: The solution comes into the saturator through tube (R), flows over the heating lamp (H), the hot stream striking the feeding crystals and becoming saturated. Before the solution returns to the crystallizer it must pass down between more crystals into the platinum gauze filter at (F); thence to the crystallizer. *En route* it is cooled slightly in the water-jacketed tube before entering the crystallizer. The supersaturated current now passes over the nuclei at (N) and excess material deposits thereon. The cooled solution returns through (R) to the saturator. The currents caused by the auxiliary stirring (A and A_1) in the thermostats are such as to assist the main circulation between the two thermostats.

Instead of depending upon chance for the formation of nuclei it is far better to introduce small well-formed crystals which have been developed elsewhere. If a warm saturated solution is allowed to cool overnight there will usually be some small crystals that are suitable as nuclei. Where these crystals have been in contact with the bottom of the vessel there is under each one a small terraced cavity. This has been brought about partly by the fact that mother-liquor did not have access to the bottom surface during growth. While growing in this manner the original nucleus may be lifted several millimeters. When these crystals are placed in the crystallizer they should be oriented with the cavity on top. New growth will soon build up the top to a plane surface. Each day the crystal should be turned over so as to avoid the development of deep hollows underneath. The crystals should likewise rest on plane glass and not on the irregular bottom of the battery jar. Before introducing crystals into the crystallizer it is advisable to dip them into a saturated solution (as in the saturator) and wash off loose particles.

It has been mentioned that the rate of growth is also influenced by the number of nuclei. With a temperature difference of 0.3-0.5° and 5 nuclei present the rate of growth for potash alum was about 1.0 mg. per hour per sq. cm. of crystal surface exposed to the solution.



The apparatus consists essentially of two thermostats,—the Saturator (S) and the Crystallizer (C); S is maintained at a temperature slightly higher than C and is about one-third filled with crystals which keep the solution saturated. The saturated liquid is pumped from S into C where the excess material is deposited on small crystals (N), after which the solution is returned to the Saturator; the course of circulation is shown by the arrows.

Section and plan of crystal-growing apparatus

The surface of the solution in the saturator was uncovered and evaporation allowed to take place—thus helping in the maintenance of saturation. In the crystallizer, however, the only supersaturation desired is that under control and consequently evaporation was prevented by a layer of kerosene floating on the solution. Crystals introduced into the crystallizer were lowered beneath the oil in a bottle.

It is of great advantage to have large crystals or aggregates of crystals for use in the saturator to serve as "raw material" from which to grow well developed crystals. In the case of the alums, for instance, large-sized material is commercially available, and such is the case with numerous other salts. Where material cannot be secured in large particles the finely-divided salt must be used and as this cannot be piled up in the saturator like large-sized material, recourse is had to the use of small bags suspended in the solution and refilled from time to time with the fine crystalline material. Under the influence of the oscillating temperature obtaining in the solution in the saturator such finely divided material soon coalesces into aggregates which are entirely suitable for this purpose.

If the presence of fine thread or of wire is not objectionable in the fine crystal the nucleus may be suspended in the solution by such means. This avoids the necessity of turning the crystal each day and also gives a more symmetrical crystal. Crystals grown around such suspensions are usable for a great variety of purposes but as pointed out previously such crystals are not suitable for pressure investigations.

Even though the crystals grown under thoroughly controlled conditions appear beautifully clear and perfect to the unaided eye, microscopic examination very kindly made by my colleague, Dr. H. E. Merwin, frequently reveals the presence of minute inclusions, the causes of which require further study. Also, it may be mentioned here that "isotropic" crystals grown under these conditions often show zones of local strain when examined in polarized light.

An observation may be recorded here regarding the development of faces on alum crystals. As normally grown such crystals form flattened octahedra, diagrams of which are shown in position in the sketches of the crystallizer. Ordinarily such crystals are nearly free from any of the related faces such as the cube and the rhombic dodecahedron; the cube face may be observed but it is always small and the rhombic dodecahedral face is even less developed. Such is the case when the crystals are grown continuously without periods of solution intervening. If, for any reason, the growth of the crystal is stopped and solution of the crystal takes place the edges of the crystal are rounded in the initial stages of dissolution; when conditions are changed so that growth recommences the rounded portion of the crystal flattens during growth and in so doing a rhombic dodecahedral face is developed. During the future growth of the crystal this new face is very prominent and in none of the cases observed here has it ever filled out to form the sharp edge of the original octahedron. A similar development of the rhombic dodecahedral face can be induced if the edge of the octahedron is removed by other means and the crystal then allowed to grow. The "repair" of crystals during growth is thus seen to follow along the lines of least resistance.

It should be emphasized here that the mere fact that all essential conditions are under control in the crystal-growing apparatus described above, is not, in itself, a guarantee that any salt can be made to form large crystals under the conditions obtaining therein. Some salts may be readily enough crystallized in large well-formed crystals—other salts under the same conditions will yield a multitude of small crystals rather than a few large ones. Potassium alum and sodium chlorate were grown very successfully in this apparatus but experiments with ammonium chloride yielded only a mass of fine, fernlike crystals instead of growth on certain crystals which had been introduced as nuclei. In this case the effect was not caused by incorrect adjustment of conditions for these fine crystals appeared and increased in size in the crystallizer, thus showing that conditions were optimum. On several occasions all crystals except one were carefully removed from the crystallizing chamber and circulation of liquid continued, but here again, instead of deposition taking place on the remaining crystal, other nuclei were formed developing later into the usual fernlike growths. These experiments were repeated under a sufficient variety of controlled conditions to show that the phenomenon was connected with certain relations which are at present beyond our control.

The literature is filled with observations on the effect of foreign material on crystal habit but experience gathered in the course of these investigations has shown that, in general, such effects have been largely overestimated, at any rate in certain classes of salts. Furthermore, it will be shown in future publications that there is nothing mysterious about the action of addition products in many cases, but that a simple explanation based on well-known physico-chemical laws will suffice to account for all the facts that have been observed under this head.

The crystals grown in this apparatus have been used in the study of certain problems connected with the linear force of growing crystals, and also the effects of nonuniform pressure on solubility. The publication of other results, delayed by the war activities of this Laboratory, will be made as opportunity permits.—*Jour. Wash. Acad. Sci.*

The Fight Against the Cattle-Tick*

How Half of Our Quarantined Area Has Been Freed of this Pest

ADVANCING well beyond the half-way mark in freeing the South from the cattle fever tick, removing the Federal quarantine from cattle shipment in 70,754 square miles of nine Southern States, driving a broad wedge of tick-free territory through the tick lines to the Gulf of Mexico—the fight against the destructive parasite must count 1917 as its greatest year so far.

December 1, when 65,520 square miles—the largest amount of territory ever freed at one time—were added to the liberated areas, was the greatest day in the campaign since it was started actively in 1906, and it was celebrated as such in the States and localities to which it signalized undeniably long strides toward realization of the South's merited position as a cattle-raising country.

Faltering, slow and uncertain at first, the advance against the cattle tick in eleven years has gained such impetus that it now literally is sweeping forward. There is now no doubt of final success and there are great hopes that the goal of "a tick-free South in 1921," which also will mean American territory entirely freed from the parasite, will be realized.

TICKS HAVE LONG INFESTED CATTLE IN SOUTH.

Cattle in the Southeastern Atlantic and Gulf States have been infested with the tick since cattle first were introduced into those regions. It is thought probable the ticks were introduced into the country by cattle from Spanish herds. The history of the tick in the South is largely a history of the agricultural life of that section. In it are intertwined the great events of a century or more that have attended the transformation of the South from a wilderness into a wide and prosperous agricultural domain.

Ticks carry a fatal disease between cattle. Calves survive the effect of it, but very few older cattle live long when attacked for the first time. But for the fact that the calf that lives after the attack becomes partially immune, there would now be no cattle in the tick-infested portion of the South. Southern cattle always have caused disease among northern cattle whenever they, carrying ticks, have left their home territory and been driven into or through adjoining territory. A notorious example of such driving occurred after the Civil War when Texas and Indian Territory cattle were driven into Colorado and Kansas, leaving death in their trails for the native cattle. This caused the "cowboy wars," in which it was sought to turn the cattle back by force of arms, and also caused the enactment of stringent State laws.

During these years of settlement the cattle tick had extended northward until its distribution was about coincident with that of cotton. From this vantage ground it was scattered by driveway and by rail into northern markets and caused annual outbreaks of Texas fever, as the disease was then called, throughout the North. Legislation in various States sought to check the disease at that time, but, owing to ignorance of the manner of its spread, was powerless.

QUARANTINED TERRITORY FIRST DEFINED IN 1889.

Finally, with the formation of the Bureau of Animal Industry of the U. S. Department of Agriculture in 1884, the Federal authorities, under authority of Congress, began the fight against the tick. The bureau first sent out agents to define the line between infected and noninfected territory, and in the annual reports of 1884 and 1885 several maps were published showing its location. The first order defining and mapping the quarantined infected territory was published in 1889. The driving or transporting of cattle from the infected to the free territory was forbidden, except for a short season in winter and except for immediate slaughter when transported by rail or boat and discharged into quarantine pens at certain recognized slaughtering centers. This constituted a quarantine which has existed with timely modifications ever since.

The beginning of tick eradication is traced to a meeting of the Commissioners of Agriculture of the cotton-growing States held in Raleigh, N. C., in 1899, when the North Carolina commissioner directed that the State's aim to improve the cattle industry by tick eradication be presented. From this beginning until 1906, twelve counties in North Carolina had been released from quarantine. The association of the Commissioners of Agriculture and various allied organizations, influenced by the eradication work of North Carolina and the results obtained by Federal, State and other investigators, together with the growing necessity of ameliorating the effects of the boll-weevil invasion, prevailed upon the United States Congress to make an appropriation in 1906 to empower the United States Secretary of Agriculture to inaugurate a plan of cooperation with the authorities of Southern States in tick eradication.

In the Annual Report for 1907 of the Chief of the Bureau of Animal Industry it was stated: "Encouraging progress has been made in the eradication of cattle ticks from the Southern States. This work, which was begun in the summer of 1906 under an appropriation by Congress of $82,500 * * * is no longer an experiment. The results already accomplished demonstrate that the extermination of this costly pest is not only possible but practicable, though several years may be required for the completion of the work."

The years since that report have been years of meeting and overcoming obstacles until now, when the real magnitude of the task can be appreciated, it is certain that nothing can permanently hold up the work.

TICK FEVER AND THE MANNER OF ITS TRANSMISSION TO CATTLE.

The story of the cattle tick (known scientifically as *Margaropus annulatus*), in relation to the part it plays as carrier of the tick-fever organism, is one of the most interesting in the annals of scientific investigation. It has been described by one writer as a "romance in pathology." It may be recalled that in the early days of our cattle-exporting trade the Texas longhorn was most prominent. It soon became known that these cattle, although apparently healthy themselves, caused a deadly disease in other cattle, the part played by the tick being at that time unknown and unsuspected. Hence the disease acquired the name of Texas fever. The tick, however, is no respecter of localities so long as they are suitable for its propagation, and tick fever occurs wherever the combination of infected ticks and cattle is present. The problem of combating the disease was undertaken soon after the Bureau of Animal Industry was organized in 1884, and a few years later the epoch-making discoveries of the bureau scientists led to the true cause of the disease being found.

The discovery that ticks can carry germs of disease from one animal to another was the first instance in which the important rôle of insects as carriers of disease was ascertained. From it arose new procedures in preventive sanitation. Since then the noxious rôles of various other insects have been learned; for example, mosquitoes carrying malaria and yellow fever; the rat flea, bubonic plague; the house fly, typhoid fever. Formerly no attention was paid to the carriers; only treatment of the patients was considered necessary. Now mosquitoes are screened out of buildings and exterminated; rats are killed; and house flies are screened, starved and "swatted;" all of which has greatly reduced the number of victims of the mentioned diseases. The discovery of tick inoculation was made through the joint efforts of several members of the bureau staff.

A systematic study of southern cattle fever, begun in 1888, developed that the disease, very similar to malaria in man, was caused by a minute protozoan parasite that invaded the red corpuscles of the blood and in acute cases destroyed them so fast that the spleen became clogged with débris from the blood, the liver filled with bile, and the red coloring matter of the blood was passed off with the urine. Intense fever developed and the animal usually died in from one to four days after first appearance of symptoms of illness. The death rate was usually low in herds with many young or insusceptible animals; among old catttle it ran as high as 80 or 90 per cent. It was further found that the disease was acquired soon after the young of the cattle tick—called seed ticks—attached to the cattle. Acquisition of the ticks was found to be governed by their life history, on which is based the science of tick eradication and also the rules of quarantine. The life history is as follows:

Adult ticks carried by cattle fall to the ground, and in about a week each female lays from 2,000 to 4,000 eggs, each of them carrying fever germs. Hatching in about three weeks of warm weather, but requiring a much longer time in cold weather, the seed ticks remain on the ground or on grasses, hungry and waiting for a chance to attach themselves to a cow or steer. Attaching themselves, the ticks hunt for places in the hide they can penetrate and, finding them, immediately begin to suck blood and to grow. Two immature stages of development precede the adult stage, when the males fall off the animal and die, and the females also fall off, but lay their eggs on the ground before they die.

ARSENICAL DIPPING VAT IS EFFECTIVE WEAPON.

The method of tick eradication found to be effective and now used almost exclusively is the arsenical dipping bath. This method will rid a county of ticks in a single season, it has been shown. For the method to be effective every cow and steer in the county must go through the bath once every two weeks during the season.

The ticks clinging to the cattle are killed by the arsenical bath. Those that attach themselves before the next bath are killed in that emersion before they have time to lay eggs. Those forced to remain in the grass die of starvation.

The dipping vat with arsenical dip was first used for tick eradication in 1909 by a Federal inspector in Alabama. He followed the method used in stockyards of dipping for scabies, and also the Federal system of oil dipping for animals carried in interstate commerce. Previous to 1909 swabbing and spraying by hand were the methods used in the intrastate work. The vat method has been found to be not only effective and speedy but to be inexpensive.

In September, 1917, 21,095 public or private vats were available in ten Southern States. The work in 336,678 square miles of territory was supervised by 272 inspectors of the Bureau of Animal Industry, 351 State inspectors, and 1,209 county inspectors.

A powerful aid in the tick fight has been the passage of State laws enabling effective Federal cooperation. In 1906, when the first Federal appropriation to inaugurate a plan of cooperation with States was made, such laws were in existence in only seven Southern States—Virginia, North Carolina, Georgia, Kentucky, Tennessee, Oklahoma and California. Since then laws have been enacted in Alabama, Arkansas, Florida, Louisiana, Mississippi, South Carolina, and Texas. The only State affected by ticks and missing from this list is Missouri, in which only four counties were infected in 1906, and which is now completely free.

Federal cooperation does not mean that the National Government builds the vats nor supplies the money and materials with which to "dip the tick" and kill it. But it does mean that the Bureau of Animal Industry of the United States Department of Agriculture furnishes trained men to supervise the work of dipping and show the people of any county how to make a beginning. Appreciation of this cooperation is shown by the fact that every State and most counties in the tick regions have appropriated public moneys to take advantage of the scientific and practical knowledge placed at their disposal by the Federal Government.

To survey adequately the benefits from tick eradication a glance must be taken at the baneful effects of infestation. Cattle not only die from the fever transmitted by the tick, but they lose greatly in blood, meat, milk production and reproductive power. The ticks suck the blood that should go to make beef and milk; prevent sale of infested cattle outside the quarantine area except for immediate slaughter and at almost any price the buyer chooses to pay; and close the door to importation of better stock to improve the quality of a herd, for new cattle brought into ticky country are easy and luscious prey for the tick.

MANY CATTLE RAISERS PRAISE FIGHT AGAINST TICK.

Benefits from tick eradication are told in hundreds of letters received annually by the Bureau of Animal Industry. The consensus of opinion in these letters indicates that on the average cattle freed of ticks are enhanced in value about $10 a head, weigh one-fifth heavier, grade one-fourth better, and are safe from cattle fever and from shrinkage on account of ticks. The letters also show that where the tick is dipped out the southern cattle industry is growing, that there is more improved blood, that the milk yield of cows is increased about one-fourth, and that there is an increase of forage crops and silos.

Here are some reasons why, in the opinion of Department of Agriculture officials, tick eradication is important, especially at the present time, and why the fight now half won must go on to complete victory:

(1) Good agriculture is dependent upon animal husbandry, and of the domesticated animals cattle are the leaders for fertilizer purposes; (2) the supply of beef is not keeping pace with the demand and must be increased to meet the needs of America and the allies in the war; (3) cotton production, menaced by the boll weevil, must be kept up by cattle fertilizer and must be supplemented by cattle raising in order that the cattle farmer may thrive and be able to raise cotton at all; (4) the cattle business of the South, long a

*Weekly News Letter of the Department of Agriculture.

negligible item in most States because of depression caused by the ticks, can be made the equal of that of any country.

The progress made so far in tick eradication is taken to mean that every square mile in the South will be freed from the cattle tick within a few years. From the areas released from tick domination and quarantine will go forth to the areas still infested not only the inspiration of accomplishment but also the practical help of the Federal inspectors released from work in the counties just freed and ready for labors in new fields.

Two Fur Seal Problems and Their Solution*

By George Archibald Clark

Academic Secretary of Stanford University

A PROPERLY informed breeder of cattle would know the ultimate or average age which his breeding stock might be expected to attain, and the annual increment of young breeders. Such knowledge would be considered fundamental to successful breeding of any of our domestic animals.

The United States Government is engaged in the breeding of fur seals on the Pribilof Islands in Bering Sea, and has been for fifty years, but has not yet definitely ascertained these two important facts with regard to its seal herd; and until five years ago no real progress was made toward ascertaining them. When we consider the amount of investigation to which the seal herd has been subjected in the last twenty-five years, this seems an incredible statement, but the explanation is simple—no investigator has ever been allowed opportunity to study the herd for more than two seasons in succession, and to solve the first of these problems would require at least fifteen years of close, systematic study. The solution of the second problem is dependent upon the first and has, in addition, elements of its own which have required five seasons to solve.

These problems are not so simple in the case of seals as in that of domestic animals. A cattle man can send out his cowboys and round up his herd at any time; he actually can count the various classes of animals. The fur seals, however, get all their food in the open sea and spend the winter in a long migration far from the reach of man. They can never all be brought together at any one time. The animals do not carry upon themselves any distinctive age markings. The seal which has begun to decline ever so little in strength and efficiency succumbs to the harsh conditions of the northern winter; only those in prime condition and physically fit return in the spring.

The three-year-old females, which constitute the breeding increment, come upon the breeding grounds gradually and mingle with the adult females, being indistinguishable from them. The two-year-old females, having no young, are even less recognizable as a class, while the yearlings of both sexes keep to the sea for the most part in the breeding season. The two, three, and four-year-old males, the animals from which the product of the herd is taken, are irregular in their movements. They frequent hauling grounds separate from the areas occupied by the breeding seals. The method of taking the quota is to have these hauling grounds driven each week during a season of from six to eight weeks. Animals of approximately three years of age only are taken; the others are returned to the sea. New three-year-old animals are found each time, and the killing season closes early in August, not because of exhaustion of the supply of killable animals, but because of an undesirable condition of the skins due to shedding. It is not possible, therefore, to determine the number of three-year-olds even by the process of elimination. Naturally no enumeration of the two-year-olds, driven and redriven as they are, can be made. Of the breeding seals, it is possible to make an exact count of the harem masters because of their large size and the fact that they do not change their positions during the breeding season. The breeding females, however, come and go in the sea, and never more than one-half of them is present on land at any one time. In short, aside from the breeding males—the smallest element in the herd—there is no direct way of enumerating any class of the grown animals. Fortunately the pups of the season do not take to the water during the first month or six weeks of their lives, and at the close of the breeding season can be driven up and counted. As each breeding female has but one pup the count of pups is equivalent to a count of females, and from this known element of the pups a fair approximation of the other nonbreeding animals can be arrived at.

These problems are not merely difficult in the case of the fur seal; they are unusually important. It is vital to the life of the seal herd that the killing of the males should not be so close as to leave an insufficient reserve for breeding purposes. It should be close enough not to involve waste; sealskins are worth approximately fifty dollars apiece. A determination of the proper breeding reserve naturally requires knowledge as to the breeding life of the male, hence, of the normal life period. To maintain a safe reserve and at the same time to take advantage of the full product of the herd requires a definite knowledge of the number of three-year-old males available in any given season. The information cannot be obtained directly.

The sexes are practically equal at birth and subject to like vicissitudes. It may be assumed that they will survive in equal numbers to the age of three years. This is breeding age with the female. An enumeration of the three-year-old females would give the needed information, but these cannot be enumerated directly. A full count of the pups for two or more successive seasons would give a measure of the herd's normal yearly gain. This annual gain results from the increment of three-year-old females but is not a measure of this increment. The annual loss in adult females through natural termination of life must be added to the normal gain to give the full number of young breeders. To obtain this annual adult loss requires knowledge of the ultimate age of the female. Under the conditions affecting seal life we have no reason to assume that either male or female survives breeding capacity, and the breeding limit and age limit may be considered identical. Thus the various problems affecting intelligent management of the fur seal herd ultimately depend upon the settlement of the question of average age or normal life span.

Fortunately we have certain accidental sidelights on the problem of age. In 1891-2-3, during the *modus vivendi* covering the period of the Paris Tribunal of Arbitration, land sealing was suspended, and a large body of young males was left to grow up in these seasons. These appeared as a conspicuous body of idle bulls in 1896-7 and the years immediately succeeding, outnumbering the active or harem bulls three to one.

In 1901-2-3, these idle bulls disappeared as a class so suddenly as to excite alarm lest the killing then in vogue had been too close. A movement for the setting aside of a definite breeding reserve of males resulted. But the disappearance of these idle bulls had nothing to do with killing conditions in the period in which they disappeared. They came into existence as a class in an abrupt and arbitrary manner; they disappeared as abruptly and arbitrarily. These animals were three years of age at the time of their exemption from killing. They disappeared ten years later, suggesting thirteen years as an approximate average limit in the case of the males.

Again, in 1896 and the years following, an experiment was carried on in the branding of female pups, to depreciate the value of their skins with a view to discouraging pelagic sealing. In the years 1900-1-2, a distinctive form of brand was used, no differentiation being made for the three seasons. A considerable number of these branded females was observed on the breeding grounds in 1909, and again in 1912 and 1913, the number being greatly diminished in 1913. No record of observations on these animals in subsequent years is available to the writer, but the conditions as noted in 1913 pointed to from twelve to fifteen years as the approximate age of the female.

These two incidents in the life of the herd throw valuable light on our problem but do not give exact data. In 1912 a beginning was made toward securing more definite information. The time was favorable because the herd was then at the lowest condition in its history, and was on the point of increase owing to the abolition of pelagic sealing, accomplished the preceding year. All problems connected with the herd were in a condition to be most easily handled. The matter was somewhat urgent, moreover, as the agents of the Government and of the former lessees of the fur seal industry were then under investigation on charges of illegal killing of seals, the question turning upon the yearling seals but involving considerations affecting the whole policy of land sealing. These charges were known to be untrue but convincing data were not available for their disproof. They nevertheless had their effect upon Congress, and in 1912 legislation was enacted suspending land sealing for a term of years, although this action involved an annual loss of approximately half a million dollars for five years. The annoyance and discredit to Government employees and the financial loss thus entailed were due primarily to lack of adequate information on the two points we have under consideration.

First, as to the annual breeding gain in the herd: A full count of the pups born in 1912 was accomplished, totaling 81,984. A count was made also in 1913, giving 92,269, a gain of approximately twelve and a half per cent. A third count was made in 1914, but by new investigators, and a gain of only one per cent. was found. In 1915 the count was in charge of one of the Government agents who found a total of 103,527. Fortunately the same agents had charge of the count for 1916, finding a total of 116,977, a gain of approximately thirteen per cent. We thus have two sets of counts each with the personal equation unchanged, and they give respectively twelve and a half and thirteen per cent. for the annual gain in the herd. These may be taken as fixing with reasonable exactness the rate of growth at about thirteen per cent.

Although the settlement of this point must await the ultimate age determination to be useful finally in fixing the number of three-year-old animals, male and female, it has yielded immediately useful information. To count the pups each season as the herd grows is physically impossible, and some form of estimate must be substituted to reach an approximate determination of its condition from year to year. It will be possible always to make a close count of the breeding families. From the five seasons in which the full count of pups has been made, average harem sizes for each individual rookery, for each island separately, and for the herd as a whole, are available which, when finally averaged, can be applied to the count of harems and depended upon at any time to give a close approximation of the size of the herd.

Second, as to the final age limit or life span: In 1912 between five and six thousand fur seal pups were branded on the crown of the head with hot irons, giving a permanent and readily recognizable identification mark. It was expected that from the survivors of this branding a certain number of animals could be killed in 1913, and from very exact animal and skin weights and measurements a standard of the yearling seal obtained. A further killing in 1914 would standardize the two-year-old, in 1915 the three-year-old, and in 1916 the four-year-old. Continued observation of the remaining branded animals on the breeding grounds, season by season until their final disappearance, was then expected to fix within reasonable limits the ultimate or average age.

The standardization of the yearlings was interfered with in 1913 by the fact that these animals did not appear on the hauling grounds in the breeding and killing season. Incidentally this disproved the charge that yearling seals had been killed, since, if they do not come to the hauling grounds in the killing season, they could not have been killed as alleged. They did appear late in the fall among the pups of the season, their natural affinities.

It is understood that enough of the branded animals were killed in 1914 to fix the standard of the two-year-olds. It may be presumed that similar data were obtained in 1915 and 1916 for the three and four-year-olds. Whether the close and painstaking observations necessary during the next ten or twelve years to determine the final disappearance of the branded animals will be made remains to be seen. The shifting personnel of Government agents, already fully occupied with routine duties of administration, is not a hopeful source from which to expect satisfactory results. If such observations are not available, the whole experiment looking to a determination of the age limit fails and will have to be begun over again.

The need of reliable data regarding the fur seal herd in these respects is one long felt by those who at intervals have studied briefly its problems. The Fur Seal Commission of 1896-7 considered the matter of sufficient importance to urge, as its one paramount recommendation, that a competent naturalist be placed in charge of the herd who should make its needs and problems his life study. This recommendation was ignored until 1909, when the fur seal service was transferred to the Bureau of Fisheries. The position of naturalist to the herd was then created, but through the death, resignation and serious illness respectively of the first three appointees, the position, at the close of the season of 1913, was still vacant and systematic work yet to be begun. In October of that year, the present Secretary of Commerce abolished the position of naturalist on grounds of economy, leaving the herd again to its own devices, except for such desultory attention as the Government agents may be able to give it.

*Read before the Western Society of Naturalists, and published in the *American Museum Journal*.

Manganese in Egypt

THE Sinai Mining Company made its first shipment of manganese-iron ore—4,000 tons—to the United Kingdom in October last. The mines are situated in the southwest of the Sinai Peninsula, about 15 miles from the coast of the Gulf of Suez, and they are connected by rail for 11 miles and by ropeway for 6 miles with the port of Abu Zenima which is well equipped for storage and loading. According to the Egyptian Ministry of Finance, the average ore contains about 35 per cent. manganese and 23 per cent. iron; large quantities of this grade are available.—*Bd. of Trade J.*

Radio Telephony—II*

Naval and Airplane Installations Developed During the War

By E. B. Craft and E. H. Colpitts

[Continued from Scientific American Supplement, No. 2259, Page 246, April 19, 1919]

After obtaining successful communication with Darien, a distance of 2,100 miles, attention was directed towards reaching the Pacific Coast stations of Mare Island and San Diego. As a test of the transmission efficiency, records were made of the quality and intensity of the speech from Arlington, each time transmission was attempted. Records were also made occasionally at Darien, but no attempt was made to fit the time of transmission into the schedule of operation of that station. Radio telephone transmission between Arlington and Mare Island was formally demonstrated on September 29th. On this date, Mr. J. J. Carty was inspecting the station at Mare Island. A demonstration for Mr. T. N. Vail was therefore arranged for this date.

Arrangements had been made whereby Mr. Vail's apartment in New York could be connected with the radio apparatus at Washington. A telephone line extended from the transmitter assigned to Mr. Vail's use to the radio telephone apparatus at Arlington. This telephone circuit was connected to the radio apparatus in place of the telephone transmitter which had formerly been used at Arlington. From Arlington transmission was through the ether to Mare Island. The telephone set which Mr. Carty used at Mare Island consisted of a transmitter connected to a telephone line leading, via the New York test board, to a receiver in Mr. Vail's apartment. The receiver of Mr. Carty's set at Mare Island was one of several which were supplied in parallel by the detector of the radio receiving set. Arrangements were thus made whereby Mr. Vail and Mr. Carty might carry on two-way conversation, but what Mr. Carty and the other observers heard at Mare Island was transmitted from Arlington by wireless.

At the new York toll board a telephone line was bridged onto the circuit leading from Mr. Carty to Mr. Vail. This line extended to Arlington and contained one-way repeaters so that transmission could take place only from New York to Arlington. At the latter place it supplied a group of telephone receivers which were also connected through a one-way telephone repeater with the line which bore Mr. Vail's speech to the radio apparatus. In this way some dozen observers at Arlington could hear both sides of this unique conversation. The use of one-way repeaters prevented any interaction between the oppositely directed speeches.

At the Arlington station the conversation was listened to by Captain Bullard, Colonel Reber, Commander Hooper, Lt. R. B. Coffman, Lt. Bastedo, Commander Bryant, and members of the telephone system. Messrs. T. N. Vail, U. N. Bethel, J. I. Waterbury, Bancroft Gherardi, and H. P. Charlesworth all conversed with Mr. Carty through the ether.

THE ARLINGTON-HONOLULU-PARIS EXPERIMENTS

Having successfully transmitted over water to Darien, a distance of 2,100 miles and over land to Mare Island, a distance of 2,500 miles, attention was now directed towards reaching the remoter points of Honolulu and Paris. Schedules were therefore arranged for experiments with these stations. With Paris, however, the arrangements as to schedules were necessarily delayed because of the difficulties in cable transmission occasioned by the war.

With Honolulu, on the other hand, arrangements for a transmitting schedule had been made shortly before the demonstration of the New York-Arlington-Mare Island transmission. The first deliberate attempt to communicate with this station occurred on the night following the demonstration to Mare Island. Mr. Lloyd Espenschied of the American Telephone and Telegraph Company, who was the experimenter at this point, reported by cable the following morning, giving a record of the words which he had heard spoken, and also the name of the speaker, whose voice he had recognized.

At Paris were Mr. Shreeve and Mr. Curtis of the Western Electric Company. These experimenters had installed their apparatus in the Eiffel Tower station of the French Army. This courtesy had been accorded our representatives by Lieutenant Colonel Ferrié, Director of the Military System of Radio Telegraphy. The magnificent spirit which France has shown throughout this bitter struggle is well illustrated by the ability of that nation to consider scientific developments, which apparently were not of immediate military value, and to assist them despite the demands of the war. The amount of time during which our experimenters could use the antenna was, of course, very limited, and was small as compared to their necessities. The permission to use the antenna at a time when France was wholly engaged in this bitter struggle represents a contribution to science altogether disproportionate to the time which the antenna was available to our men. Unfortunately, however, much of the time when Mr. Shreeve and Mr. Curtis had access to the Eiffel Tower antenna there was interference from other high power stations on the Continent, such as Nauen, Eilvese, Clifden, Norddeich, Lyons and Vienna, which were transmitting upon the same range of wave lengths as it was necessary for us to employ. Instructions from Paris to Arlington, to alter the wave length of the transmission, could be forwarded only by cable, and were, of course, subject to days of delay, so that a satisfactory and flexible working schedule was not to be hoped for. Further, it was possible to transmit in any one day only for a brief period. In spite of these difficulties, promising results in the way of clearly received speech at Paris were secured during short periods that it was possible to arrange for working, between October 12th and October 21st. On October 23d as a final demonstration a number of observers, including Commander Sayles and representatives of the French Army, listened to the telephone transmission from the Arlington station 3,600 miles away. The wave length used was about 6,000 meters and the antenna current at Arlington about 50 amperes.

On certain of the occasions when we had worked to Paris, Mr. Espenschied at Honolulu had been informed as to the schedule of tests. He had therefore listened in and copied the words spoken at Arlington. The conditions at his stations were, of course, much better than at Paris because of the absence of interference from high power stations in the neighborhood. His observations were upon transmission over a distance some 25 per cent, greater than that from Arlington to Paris, and in part over land as well as sea water.

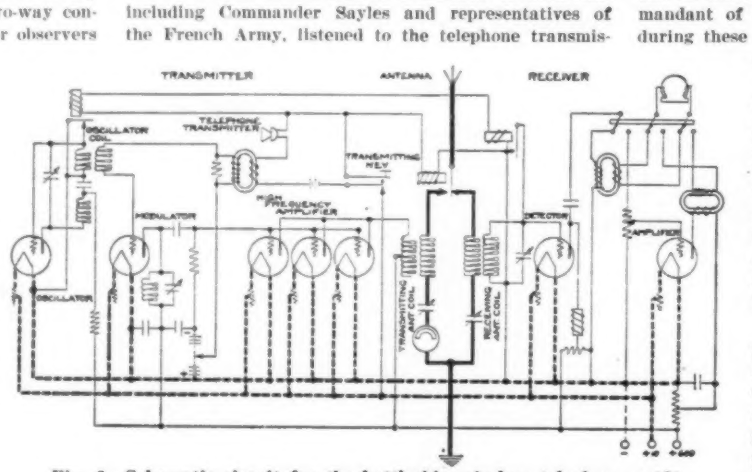


Fig. 3—Schematic circuit for the battleship wireless telephone outfit

PRACTICAL DEVELOPMENTS

The impending danger of war put an end to the experiments as far as they were concerned with increase in range of transmission. The possibility of applying the principles which had been successfully developed in connection with these experiments in trans Atlantic and trans Pacific radio telephony to problems of immediate and patriotic value was of course evident. Subsequent developments and experimental tests were therefore directed solely with an aim toward their military value to the Army and the Navy.

The first opportunity to demonstrate the use of the wireless telephone in war was presented early in 1916. Secretary Daniels desired a demonstration of what could be accomplished in the way of mobilizing the telegraph and telephone facilities of the country in case of wartime need. This was carried out in May, 1916, and included as part of it wireless telephone communication with a battleship at sea.

The part played by the wireless telephone was to show the possibilities of quick communication by word of mouth between vessels at sea and Headquarters on land. A complete set was built and installed on the battleship New Hampshire. The transmitting to the battleship was done from our station at Arlington. The signals from the battleship were received at the Navy Yard at Norfolk with a set built for that purpose, and were automatically transferred to land telephone lines to Washington. The connections were brought directly to the mobilization switchboard at the Navy Department Annex. When it was desired to talk to the battleship, the regular telephone circuit from the Navy Department was connected up with the lines to Arlington and Norfolk, thus allowing communication by telephone to be held directly with the Captain of the vessel. It was found entirely practicable to hold two-way radio communication as effectively as over wire lines and to secure information or to give orders. Captain Chandler received his orders for maneuvering in this experiment by wireless telephone from Secretary Daniels and Admiral Benson, and he reported to them each hour his position by the same means. The fact that the lines to the transmitting and receiving land stations came to Washington where these gentlemen were located did not mean that such an arrangement only was possible. This radio system was attached to the long distance telephone line and Capt. Chandler talked with Lieut. Snyder of the Great Lakes Naval Station. It was then connected with the Transcontinental Telephone Line and he talked directly with Capt. F. M. Bennett, Commandant of the Mare Island Navy Yard. The ship during these conversations was 50 miles from Norfolk and outside the Capes.

The set installed on the New Hampshire differed from the set at Arlington only in size. The general circuit arrangement and modulation system was the same. The set was installed on the lower bridge deck and the telephone transmitter and receiver were installed on the bridge itself. This allowed the Captain, while on the bridge and directing the movement of the ship, to converse without leaving his post.

The possibilities of the wireless telephone in Naval Maneuvering were quickly recognized by the Navy Department. Commander Hooper of the Bureau of Steam Engineering asked us to cooperate in making the wireless telephone a useful piece of equipment in Naval service. It was decided to build two experimental sets, install them on battleships and give the operating staff an opportunity to investigate and criticize them from an operating point of view. The construction of two sets was begun in December, 1915, and they were completed about the middle of January. Each set consisted of complete transmitting and receiving sets with a motor-generator. The receiving set was built to be set on top of the transmitting set. An extension circuit was provided so as to allow placing the hand set either on the bridge or in the Admiral's cabin so that it would not be necessary for them to go to the radio room to talk. A duplicate hand set was provided for the operator in the radio room as well as a head telephone for listening-in. The normal condition of the circuit was with the antenna connected to the receiving set. Any call thus coming in would be received. When a call was received and it was desired to talk instead of to listen, a button on the hand set was pressed which caused the relay-operated antenna switch to disconnect the antenna from the receiving set and connect it to the transmitting set and at the same time start the transmitting set operating. This operation required only a fraction of a second. It was thus possible to transmit and receive successively on the same antenna by pressing the button whenever it was desired to talk. The wave length range of the set was 600 to 1,200 meters. The circuit is shown in Fig. 3. This system was likewise similar to that at Arlington, but was, of course, quite small and produced only one and one-quarter amperes in the antenna. These sets were installed on the battleships Arkansas and Florida at Guantanamo, Cuba, the first part of February, 1916. It was found entirely practicable to hold a two-way conversation between vessels

*Presented at the Convention of the Amer. Inst. of Elec. Engs. in New York. Copyright by the Institute and reproduced by permission from its Transactions.

over 30 miles apart. There is no reason to think that was the limit of communication as some of these conversations were overheard in Jamaica, a distance of 175 miles. No attempt was made for range, as that was not the object in building these sets.

MULTIPLEX WORKING.

This experiment pointed out many things in the use of the wireless telephone which it was highly desirable to know. As the result, the Bureau of Steam Engineering approached us later in the same year and requested that a second step be made in the development of a satisfactory set. The fact that this set worked on the same wave lengths as their regular radio telegraph sets, caused considerable interference. It was desired in the telephone field to provide separate possibilities in communication for the Navy and not encroach upon the telegraph. It was, therefore, thought desirable to go to much shorter wave lengths and provide a set which would not interfere at all with the telegraphic operation of neighboring vessels and interfere very little with the telegraphic operations on the same vessel on which the telephone was being used. A few field experiments were made with short wave antennae on two ships in July, 1916, to provide data necessary for building these sets and their design and construction was started in October. The new set differed from the old one in that it operated on three wave lengths, 150, 189, and 238 metres, and also in that it was multiplex and allowed nine conversations to be carried on three wave lengths. The basis of the multiplex system which was originated by Mr. R. A. Heising is as follows:

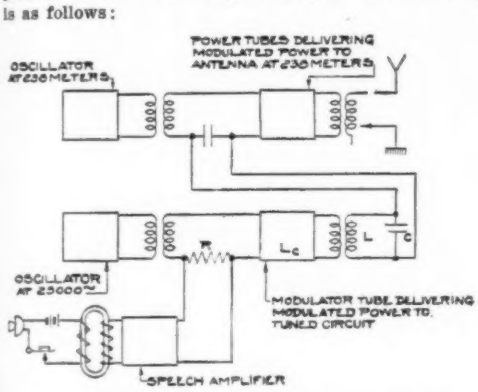


Fig. 4—Scheme of the multiplex arrangement

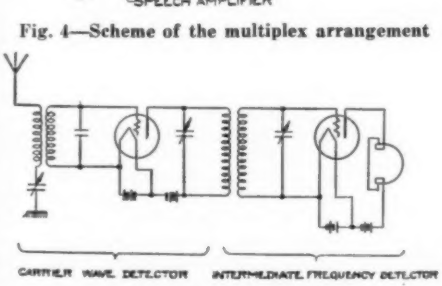


Fig. 5—Schematic of the multiplex receiving circuit

Suppose a wave of 25,000 cycles is modulated according to a speech signal. This wave when received in the receiving set and rectified reproduces the desired speech. If, however, instead of radiating this 25,000-cycle wave directly, we modulate a 150-meter wave with it and radiate the 150-meter wave, on receiving and detecting at the receiving station the 150-meter wave there will be produced the wave of modulation, or the 25,000 cycle wave. This second wave is, therefore, produced in the receiving station not by its direct radiation and reception, but is produced there by being carried by the shorter carrier wave. If it is then selected by tuned circuits and detected, the speech signal becomes audible. Therefore, with these sets provided, it was possible to have three ships transmit simultaneously on the same wave length, 150 meters for instance, one ship using an intermediate frequency of 25,000 cycles, the second an intermediate frequency of 35,000 cycles, and the fourth an intermediate frequency of 45,000 cycles. A receiving station tuned to 150 meters would receive all three double modulated waves. By using a second tuned circuit, one of the stations could pick out any one of these three conversations by tuning the second tuned circuit to 25,000, 35,000 or 45,000 cycles and detecting and would not be interfered with by the other two stations on the same wave length. A schematic diagram of the system is given in Fig. 4 and a circuit diagram of the receiving system is given in Fig. 5.

Beginning with the entry of this country into the war, the demands for radio apparatus for military purposes have resulted in the very rapid commercial development of this type of equipment. While nothing fundamentally new has resulted from this work, there has been a very practical and valuable result in that the commercial development and manufacture of radio telephone apparatus in general has been put on a basis which otherwise could not have been reached for many years to come.

AIRCRAFT TELEPHONY.

The most prominent and probably most spectacular development of radio telephony during the war was in connection with its use on military aircraft. While radio telegraphy had been used before for fire control and scouting purposes, its field had not gone beyond that of one-way communication, and was confined practically to the use of simple spark-gap types of telegraph apparatus.

Anticipating possible employment of radio telephony in this field, the Western Electric Company engineering organization had done a considerable amount of experimental work in the way of applying the principles demonstrated in connection with earlier experiments in long distance radio telephony to short range work. This work had been carried on for some time under the direction of Mr. H. W. Nichols, and had resulted in the development in experimental form of satisfactory short range apparatus.

On May 22, 1917, Major General Squier, Chief Signal Officer of the Army, called a conference at Washington to consider the feasibility of intercommunication between airplanes while in flight by means of radio telephony. At this time plans were in the making for the tremendous aircraft program which was later undertaken by the Army, and it was clear to all that a successful means of communication between battle planes when flying in squadrons would be of inestimable value and would greatly increase the efficiency with which these squadrons could be maneuvered. The early work had shown such promise that there was justification for assuring the Signal Corps

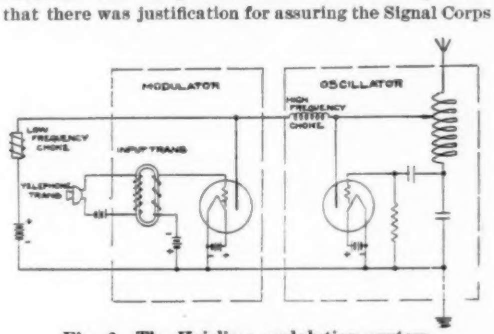


Fig. 6—The Heisling modulation system

that this means of communication could be worked out successfully and applied to aircraft of various types. As a result of this conference, orders were issued to undertake the development of a wireless telephone system for the purpose. The experimental equipment available as a laboratory proposition at this time, served as a basis for the first experimental trials in the air. This transmitting set did not use the Colpitts system of modulation but the "constant current" system of R. A. Heising, which was found to be more compact and easily operated. This system comprises a modulator and an oscillator tube with their plate circuits essentially in parallel for audio frequency currents. They are supplied from a generator through a choke coil whose function is to maintain a practically constant current to the two tubes no matter how the plate currents may vary individually. A circuit diagram is shown in Fig. 6 and the operation is as follows:

When the transmitter is not actuated there is a certain normal value of voltage impressed upon the grid of the modulator tube, this value being adjusted until the plate current of the modulator is about the same as that of the oscillator. Now the characteristic curve of Fig. 1 (last week) shows that as the grid becomes more negative the plate current decreases at constant plate voltage, and with positive grid voltage it increases. This may be described by saying that the resistance of the plate circuit may be varied by varying the grid voltage, and inspection of the curve shows that this variation may be from a very high value (point—E) to a small value for positive grid voltages. In the modulating system of Heising the transmitter voltage acts upon the grid of the modulator and causes the resistance of the plate circuit to vary through a wide range in accordance with the speech voltage. Since this circuit shunts the plate circuit of the oscillator tube (at audio but not at radio frequencies) the oscillator will be robbed of current or have additional plate current forced through it in accordance with the speech voltage. Its output will thus be varied and it has been found that speech is modulated in this way with very good quality. The efficiency of this system is high and greater than that of an "absorption" system in which power is variably diverted from an oscillating circuit and wasted in a modulating device. In the constant-current system the voltage and current in the oscillator rise periodically to nearly twice their values when the transmitter is not acting, which fact accounts for the increased efficiency.

This fundamental plan seemed to be the most feasible one to pursue and on June 5, 1917, another conference was held at Washington to agree upon the various technical features and make plans for carrying out field tests.

It was early realized that the principal difficulty in airplane telephony would be the noises due to the motor and the wind, so that attention was concentrated on the problem of providing against this difficulty both in the transmitting and receiving ends of the combination. Laboratory work was directed particularly toward producing a form of telephone transmitter or microphone which would be as insensitive as possible to these extraneous noises and at the same time be responsive to the voice frequencies. In order that this work might be carried on at high speed, a sound proof room was constructed and a device provided which reproduced very accurately the noises of the engine exhaust. By the first of July experiments looked sufficiently promising to warrant tests in the field. On July 2nd a complete radio telephone transmitting equipment was taken into the air and speech of good volume and quality was received on the ground, with the transmitting plane two miles away. The development of a suitable receiving head set was carried on

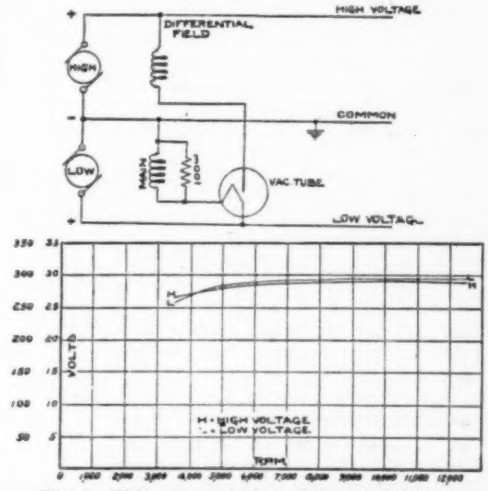


Fig. 7—Voltage regulation of the wind-driven generator for airplane use

simultaneously and it was found possible to devise a leather helmet with the receiving elements so disposed and screened from external noises that the weak radio signals could be readily observed. On July 4th experimental receiving equipment was taken into the air and Mr. L. M. Clement successfully received speech from the ground at a distance of several miles.

As stated before, the apparatus used in these tests was of an experimental form built in the laboratory. The transmitting set had an output of 0.7 amperes at a wave length range of 200 to 400 meters, the antenna being a trailing wire about 100 meters long.

DEVELOPMENT OF APPARATUS.

With the information resulting from these tests, the development of a practical airplane set began at once. During the previous month, comparative tests had been made on a number of proposed modulating systems, with the result that the constant-current system previously described seemed best for the purpose. The problem now was to produce sets of minimum size and weight, physical structures which would withstand the extreme vibrations and jars encountered in flying, especially in landing, the most convenient disposition of control elements, suitable sources of power for both high and low voltage, and a form of antenna which would not interfere with the evolutions of a plane in squadron formation.

It was realized that the solution of the last mentioned problem would consume more time than was at our disposal, and while work was immediately started in the field on antenna measurements and study, the design of the sets proceeded on the basis of using a trailing wire antenna.

The working out of a practical helmet design proved to be more difficult than the success of the earlier experiments indicated. It was found that the degree of interference experienced changed very rapidly with slight imperfections in fit. The problem was also complicated by the necessity of providing means for using oxygen at high altitudes, and of providing for the comfort of the wearer over a period of several hours. It was found that a very slight amount of pressure on certain portions of the ear caused excessive pains and headaches after a very short period, and the final design was a compromise between comfort and efficiency as to sound insulation.

The problem of power supply was an interesting one. It was required that the weight should be reduced to a minimum, which precluded the possibility of employing storage batteries. There are obvious objections, also, to attaching any form of generating device to the propelling engine. Consideration of all the factors led to the adoption of a wind-driven generator for the purpose. This generator of about 100 watts direct current output was required to produce a potential of 300 volts for the plate circuits of the vacuum tubes, and a potential of 25 volts for the filament circuits. It is necessary, to insure most efficient operation, that the filament current be kept constant, and the fact that the specifications called for operation with airplane speeds varying from 40 to 160 miles per hour made the problem of voltage regulation loom large. Ordinary forms of electro-mechanical regulating devices did not prove to be successful, and while it was probable that something of this type would eventually have been developed, the problem was solved by a very ingenious arrangement proposed by Mr. H. M Stoller, in which the vacuum tube is the essential element. Fig. 7 shows, schematically, the generator and regulator circuit.

The voltage of the generator is held approximately constant by means of a vacuum tube regulator, which controls the field flux. Two field windings are provided, the main field, which is in series with the filament of the regulator tube, and a differential field which is in series with the plate circuit. At minimum speed the differential field is inactive and the generator behaves like an ordinary shunt machine, except that the main field has a small resistance in series due to the regulator tube filament. This filament is so designed that the main field current heats it to a temperature which gives a small electron current. This current flows through the differential field and reduces the resultant flux. At minimum speed, the differential current is small, but as the speed increases, the main field current tends to rise (as in any shunt generator) and this increases the temperature of the regulator tube filament. The electron current is, therefore, considerably increased, which current, flowing through the differential field, reduces the generator flux and thus restricts the rise in voltage. Due to the fact that the electron current of the regulator tube increases very rapidly with increase in filament current, the voltage is held practically constant between 4,000 and 12,000 rev. per min. The 1.5-ohm resistance units are provided so that the regulator may be set to give different voltages by cutting them in or out of the main field. The 100 ohms shunt resistance is used to prevent hunting.

Upon the completion of the next set of models, field tests were resumed and on August 20th the first two-way telephone conversation between two planes in the air was successfully accomplished. After this first trial, Major Bartholf and Lieut. Stevens of the Signal Corps held two-way conversation between planes with very satisfactory results.

At the time of the August tests at Langley Field two general schemes of control were considered,—manual means for transferring from the transmitting to the receiving position, and automatic means for accomplishing the same result through the operation of a remote control relay. It was concluded, because of its simple construction, to employ the manual means of control, the idea being to locate the set in the observer's position in the plane.

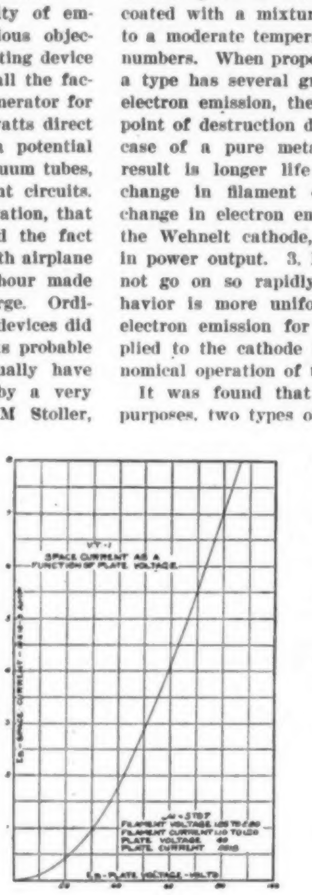
On August 22nd an informal demonstration of talk from airplane to ground was given for Secretary of War Baker, General Scott, and Colonel Baker. These experiments conclusively demonstrated the practicability of the system and apparatus, and we felt justified in proceeding with its commercial development.

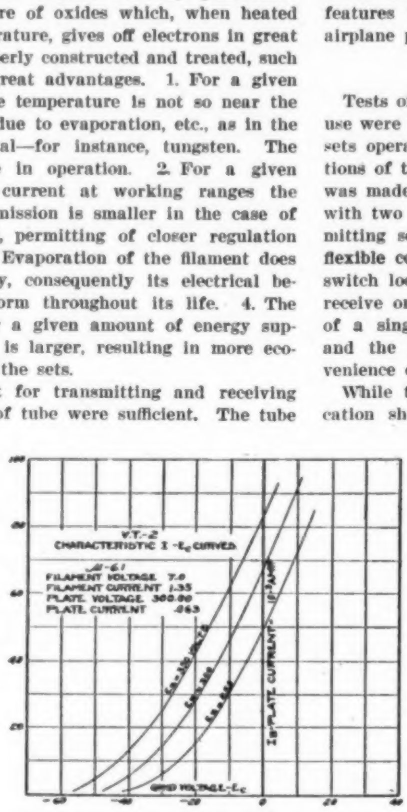
COMMERCIAL DEVELOPMENT OF VACUUM TUBES.

While the vacuum tubes that had been developed in the 1915 and 1916 experiments were satisfactory in operation under normal conditions, it was found that the mechanical vibration encountered in the air was such as to necessitate special structures to withstand them. New forms of vacuum tubes, which successfully met these requirements were developed. The tubes used in all this work were of the so-called "Wehnelt Cathode" type; that is, the electron-emitting cathode consisting of a metal filament—usually platinum—coated with a mixture of oxides which, when heated to a moderate temperature, gives off electrons in great numbers. When properly constructed and treated, such a type has several great advantages. 1. For a given electron emission, the temperature is not so near the point of destruction due to evaporation, etc., as in the case of a pure metal—for instance, tungsten. The result is longer life in operation. 2. For a given change in filament current at working ranges the change in electron emission is smaller in the case of the Wehnelt cathode, permitting of closer regulation in power output. 3. Evaporation of the filament does not go on so rapidly, consequently its electrical behavior is more uniform throughout its life. 4. The electron emission for a given amount of energy supplied to the cathode is larger, resulting in more economical operation of the sets.

It was found that for transmitting and receiving purposes, two types of tube were sufficient. The tube for receiving purposes was designated as VT1 by the Signal Corps and as the CW933 by the Navy. A transmitting tube capable of delivering a moderate amount of power—say from 3 to 5 watts high-frequency output—was known as the VT2 by the Signal Corps and as the CW931 by the Navy. Vacuum tubes are defined, as far as electrical characteristics in normal operation are concerned, by plate and filament voltages, plate current with normal plate voltage and zero grid voltage, normal filament current, filament life at this current, and by what is known as the amplification constant, which is approximately the ratio, μ, of that change in plate voltage which produces a given change in plate current to the change in grid voltage to produce the same change in plate current.

Some of these relations are conveniently shown in characteristic curves. The plate current-grid voltage characteristics of the *VT1* and *VT2* tubes are shown in Figs. 8 and 9. On these illustrations are given also the other data mentioned above.





Figs. 8 and 9—Electrical characteristics of the receiving (left) and transmitting (right) tubes

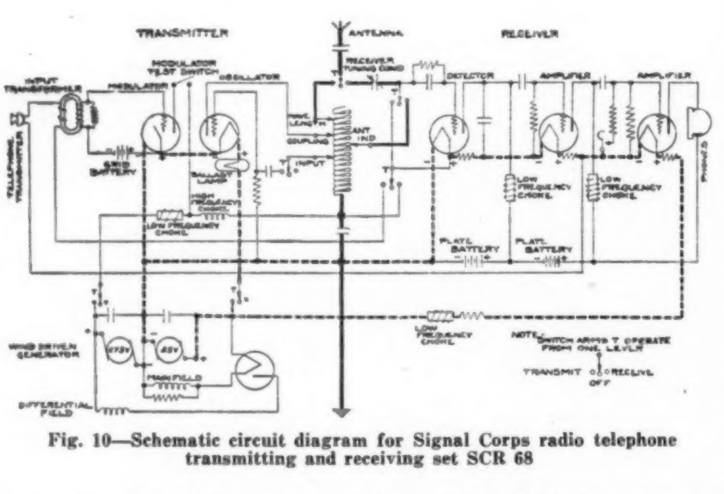


Fig. 10—Schematic circuit diagram for Signal Corps radio telephone transmitting and receiving set SCR 68

As indicating some of the problems involved in the commercial production of this entirely new type of equipment, it is interesting to note that prior to August, 1917, the total output of commercial vacuum tubes of this general type was approximately 200 per week, their use being practically confined to long distance wire telephony and to radio detection purposes. On November 11th, 1918, deliveries were being made at the rate of 25,000 per week. This involved the organization of equipment and personnel to do a class of work for which there was practically no experienced talent available and the situation in many features was analogous to that in connection with airplane production.

APPARATUS.

Tests of the first standardized sets for Signal Corps use were made at Langley Field on October 6th. These sets operated very successfully and official demonstrations of two-way communication were made. This set was made up of a combined control panel and receiver with two stages of amplification and a separate transmitting set, the electrical connections being made by flexible cords. By means of the multi-contact manual switch located on the control panel, the operator can receive or transmit as desired. The receiver consists of a single tuned circuit of the very simplest type and the amplifier is made adjustable for the convenience of the observer.

While the original requirement was that communication should be maintained at a distance of 2,000 yards, all of the tests indicated that successful communication could be obtained at much greater distances. On October 16th an official distance test was made, and communication between planes was maintained at a distance of 23 miles, and from plane to ground, 45 miles. The conditions under which these tests were made were extremely favorable, and are noted merely to show the possibilities of this particular equipment. The figure that was finally established as being representative of what would be required in service was three miles.

A number of sets were immediately constructed, and complete equipment sent overseas with Signal Corps Officers, where they were submitted for the criticism of our military forces.

Several more demonstrations of this apparatus were made, culminating in the official trials at Dayton, Ohio, on December 2nd, 1917. There were present members of the Aircraft Production Board and the Joint Army and Navy Technical Board, and various Signal Corps Officers. The demonstration consisted of a three-cornered conversation between two planes in the air and a ground station. At the ground station a loud speaking receiver was connected to the radio set in such a way that the entire party of about thirty could overhear the conversation between the fliers and also the speech between the planes and the ground. Under orders transmitted from the ground station, the fliers performed various evolutions in the air, and the observers could see these orders carried out and hear the acknowledgments. In these tests the pilot and observer in each plane were also connected, so that there were five people in constant communication. The maximum distance of the planes from the ground station was about eight miles, at which distance they were invisible. These tests so conclusively demonstrated the possibilities of the successful use of this apparatus, that quantity orders were immediately placed by the Signal Corps.

The time elements were very short and the problem of adapting the designs to commercial quantity manufacture were many and intricate. This probably is the first instance on record in which the production of radio apparatus, either telephone or telegraph, has been put on a manufacturing basis, in quantities comparable with that obtaining in ordinary lines of electrical manufacture.

The apparatus represents not what would be designed and built under normal conditions with time available for proper study of all the technical features involved, but the best compromise, bringing in such

factors as the use of standard parts, available manufacturing facilities and finally the imperative need of haste.

Information from abroad was at times conflicting and inadequate, so that the Signal Corps Officers in Washington were often required to render decisions on important points under exceedingly difficult circumstances. We are greatly indebted to Lieut. Col. N. H. Slaughter and other officers of the Signal Corps for their effective co-operation in the solution of difficult problems arising from all these causes.

The final standardized form of two-way airplane set is known by the Signal Corps as the SCR-68 set. The elements are so arranged that they can be mounted in the space available in various parts of the machine. The main set, however, necessitates being accessible to the operator. The switch box is to provide for communication between pilot and observer by means of the same helmets and microphones as are used for radio communication. This is one of the interesting by-products resulting from the radio development. Heretofore the only practicable means of communication between pilot and observer was by means of manual signals. With the telephone equipment, satisfactory intercommunication could be provided at all times. This has been found very useful in connection with the training of fliers as well as in military operations. The transmitting and receiving set is approximately 17 by 10 by 7 inches in dimensions, and weighs 21 pounds.

The wind-driven generator is usually mounted in the slip stream of the propeller on one of the struts of the landing gear. The weight of the complete equipment including generator and two operator's sets is approximately 58 pounds. Fig. 10 shows, in simplified form, the electrical circuits.

When receiving only is required, the transmitting portion is omitted, and power is supplied to the filaments by a small storage battery.

Modifications of the SCR-68 sets adapted to different classes of service were developed and manufactured, one of the principal adaptations being a combination transmitting and receiving set for use on the ground. This set was employed principally for training purposes. With this means of communication at hand, the performance of the student could be observed in the air and his faults could be corrected by the instructor on the ground, thus greatly accelerating this training work. Energy for this set was provided by storage batteries, a dynamotor being operated by the storage battery to supply the plate potential.

Up to the time of signing of the Armistice, many thousands of these sets had been manufactured and delivered.

[TO BE CONCLUDED.]

Water Power in California

(*Continued from page 261*)

were fully capable of generating 40,456 horse power.

The U. S. Geological Survey is authority for the statement that the water power in California ranges from over 3,200,000 horse power at low water to 7,800,000 horse power at high water.[4] In 1917 less than 8 per cent. of the available power was being utilized. There are various indications that this proportion will be materially increased during the next few years. Rapid industrial development, increasing municipal needs of power for electric street and interurban railways and for street lighting, additional power for pumping irrigation water when no wind is available—all these demand accelerated hydroelectric development. In 1914 there was about 500,000 primary horse power used in manufactures. It is estimated that the demand in 1918 is about 50 per cent. greater. Ocean steamers are given preference in coal deliveries, oil and labor are increasingly difficult to obtain, and the price of each is steadily rising. Increased hydroelectric development would ease the situation, and the benefits derived would extend beyond the borders of the State.

FUTURE DEVELOPMENT.

As water power consumes no fuel, its substitution for steam power would release to other uses all the extensive transportation facilities now engaged in moving fuel. It would also release a considerable volume of labor which could be used to advantage in other fields. In 1917 there were some 3,000 miles of electric railways in California, the greater proportion of which were operated by hydroelectric power. Eventually all of this mileage and more will be so operated. There were also over 12,000 miles of steam railroads in operation. In time a large portion of this mileage will be electrified. Plans are already under consideration by the Southern Pacific Railroad to electrify its mountain division. The Western Pacific Railroad crosses the Sierras along the Feather River Canyon, at the very edge of a mountain torrent in which more energy goes to waste each year than is generated in all the steam locomotives operated by that company.

The future of water power development in California, however, is not without its difficulties. Some of the undeveloped power sites are too remote from the market to be utilized at present, and an uncertain number are not yet commercial prospects. The initial cost of installation of a modern hydroelectric plant is relatively high, and for that reason water power development is necessarily delayed when the demands for capital are so varied and urgent as they are at present. In order to prevent unavoidable interruptions of hydroelectric power an auxiliary steam plant is necessary, and this adds to the cost. For sentimental reasons various waterfalls, which are situated in recreation centers like the Yosemite National Park and are aesthetically beautiful, will not be immediately available for development but must eventually be put to use. (See Fig. 2.) Furthermore, California is a region of frequent earthquake disturbance. Weather Bureau records show that this is the region of greatest instability in the whole United States. However, engineers now take these seismic disturbances into consideration in planning dams and aqueducts, which, as at present constructed, are practically earthquake-proof so far as these frequent but slight disturbances are concerned.

While there are thus a few minor handicaps to water power development in California, they are relatively unimportant and are being eliminated. The possibilities for hydroelectric development in this State are so vast as to have attracted the interest of the most efficient engineers and the foremost financiers of the United States.

[4] *Ibid.*, p. 56.

Playertype Photo Copying Process

PROBABLY a majority of those who read the title of this article have not heard of the method which bears that name: for, although it is now more than twenty years since it was first made public by Mr. J. Hort Player, it has received very slight attention, for reasons into which we need not go at the present moment. It was at the London Camera Club in 1896 that he exhibited for the first time a number of photographic copies of prints and engravings, made by contact from the originals; but by contact in a method which until actually tested must have seemed to be impossible. For instead of printing through the original on to the sensitive surface, the light which gives rise to the image in Playertype passes through the sensitive layer to the original.

It presents no particular difficulties, beyond that of ascertaining the necessary exposure; and this can be done by making a series of trials on a single sheet, in the way described often enough in these pages. Nor does it call for an elaborate equipment in the way of apparatus. In addition to the original to be copied, all that we need is a sheet of bromide paper of the same size, with developer and hypo, and some sheets of glass, a little larger than the bromide paper.

Our own most successful results were obtained with a semi-glossy paper, developed with hydrokinone. Probably any other clean working developer giving density readily would answer the purpose, but on this point it would be necessary to make a few trials before speaking definitely. In any case, the composition of the developer, except so far as we have just mentioned, does not appear to play any part in the practicability of the method.

Briefly, the procedure is this. The print to be copied—a strong line subject, such as a cartoon from "Punch," is the most suitable—is placed on a flat surface, face upwards. A few sheets of smooth soft paper form a suitable support for it. In the dark room a sheet of bromide paper in placed face downwards on the print, and is pressed into good contact all over by putting on top of it a sheet of thick plate glass or its equivalent. We used a bundle of about a dozen old negatives, carefully cleaned from all trace of film, and bound together at the edges for convenience of handling. Exposure is made by gas or lamplight, so arranged as to shine through the glass, and through the bromide paper. The paper is then developed and fixed. It will be found to yield a negative of the original, from which prints can be made in due course.

The curious thing about the process is that all the light falls on the unprotected bromide paper, from the back. This gives rise, as might be expected, to a certain amount of fogging; but, what would not be anticipated, that fogging is not so great as to interfere with the formation of a good vigorous image.

Mr. Player, in his first accounts, described how he used a green, and subsequently a yellow, glass in contact with the bromide paper. This he found gave a clearer image: but the plan just described worked quite well in our hands.

The exposures vary according to the light available; but with a carbon filament 16 c.p. lamp, held about a couple of feet above the glass, we found 6 or eight seconds gave the best result. The speed of the bromide paper must be taken into consideration, of course, and the comparative opacity of the paper stock on which it is coated. It would be quite simple to screen the arrangement with a piece of card, so as to obtain a number of different exposures on a single sheet, which would indicate what was required. Or a sheet might be cut up into a number of pieces, each of which could have a different exposure, a note being made in pencil on the corner of each, what that exposure was. Development must be carried out in the dark room, if bromide paper is used; but it is quite possible that gaslight paper with a suitably powerful illuminant could be employed.

It is not difficult to understand how it is that such a process is possible, although it may seem to be very surprising that it should be so, at first sight. Every sensitive photographic film we use, whether for negative making, or for printing—with the possible exception of carbon tissue—allows a great deal of the light which falls upon it to pass through unabsorbed. This is evident to the eye by holding a plate up to the light, and the photographic activity of the light transmitted can be shown by placing one plate behind another in the camera. On development we shall obtain an image upon both, although the hinder one will not only be blurred by the diffusion or scattering of light by the front film, but will also be much less exposed. That is only to be expected.

In "Playertype," a good deal of the light falling on the back of the sensitive paper passes right through it to the print which is in contact with its face. Here it is affected according to the character of the surface. Where it encounters the black, non-reflecting surface of the printing ink it is absorbed, and has no further effect upon the sensitive film of emulsion. Where it meets white paper, however, a good deal of it is reflected back on to the sensitive surface which is in close contact with it. So that those parts of that surface which lie against the whites of the print are exposed to a greater total intensity of light than those which are against the black parts. On development, the result of this is to obtain a negative image of the original, which may be given sufficient contrast to yield a good print.

Although the applications of such a process as this are necessarily very limited: there are some purposes for which it has its uses. It is not always convenient or practicable to copy illustrations, prints, etc., with the camera. Many photographers who wish to do a little copying at times, have not got a camera which will extend far enough to allow them to make copies the full size of the original. Copying by artificial light, without some special conveniences, calls also for a very lengthy exposure; whereas the exposures in "Playertype" are quite short. Moreover, to copy a print as large as 12 x 10, let us say, necessitates the use of an outfit much larger than most amateurs have at their disposal, and an expensive plate: while for the method which we have just described, nothing more is needed than a sheet of bromide paper of the required size and the glass. It allows copies to be made from originals on opaque mounts, or with printing on both sides of them, or in books, which might not be easily fixed upon a copying easel.

Against these advantages must be set the drawbacks that all the copies must necessarily be of the same size; and that originals with half-tones, while not quite impracticable, are at any rate not very easily dealt with. For line drawings in good black ink on white paper or Bristol board, for engravings and prints, the method presents no serious difficulties of any kind.—*The Amateur Photographer.*

Bitter Sweets

SPEAKING of sugar, there was a tragedy experienced in Canada by a body of French monks who migrated thither. They knew that a popular sweet was obtained from the famous Tree of Canada, so they went forth into the woods and tapped and collected sap and boiled it down and put their maple syrup upon the market in beautiful packages. But, alas, nobody would eat it! Investigation disclosed that the holy men, in their abundant and unquestioning faith, had tapped every old tree near the monastery, and this boiled-down juice from pine, hickory, spruce, maple, etc., did not appeal to the American palate.—*Little Journal.*

Inorganic Complexes

(*Continued from page 259*)

is born of the difference which has been established to be a fact with regard to molecular constitution between the water of hydration and the water of constitution. Thus the three hydrates of chromic chloride, one of which is violet while the other two are green, are isomers. As for the isomerism of valence, Werner deduced this from his study of the rodo- and the eritro-cobaltic salts, which led him to conceive the possibility of passing from certain oxycobaltic salts to the eritro salts when the first fix one molecule of acid and have the oxygen attached directly to two atoms of cobalt. This is demonstrated by all we know in regard to such compounds. To these species of isomerism the tautomerisms must be added, and many of these can be connected with the relations which exist between the cyanic and the isocyanic ethers, as Joergensen has shown. According to Urbain, Joergensen regards the isomerism of the flavo- and croceo-cobaltic salts as a sort of tautomerism.

It may be supposed from the foregoing remarks that Werner's ionic formulas and his representation of molecular structures have only a limited value, however extensive the limits may be. While these formulas may suffice to explain many very important phenomena, there are others for which they appear incapable of furnishing an interpretation and there exist some isomerisms which the system fails to represent. To sum the matter up, the plane formulas do not suffice to represent all possible cases of isomerism nor even to express the constitution and the transformations of complexes. For this reason it is necessary to employ stereochemical representations and formulas indicating three dimensions in space.

The stereochemical constitution of isomeric complexes can readily be imagined. We know that the simplest of them contain one metallic atom directly united by means of six valences of coordination to six groups, forming a complex radical. This fundamental fact is demonstrated by the number of ions formed in the solution of metallic complexes and by all the isomerisms of which the molecule thus formed is capable. Symmetry is the principal character of the six groups which unite with the central atom, since the valences of coordination of the latter possess an equal amount of energy; but the nature and the relative position of the groups is capable of change and we can deduce therefrom the constitution and the structure of the complexes and the formation of its isomers. It may be recalled here that in a great number of them the index of coordination is a constant equal to six.

By supposing that the metallic atom occupies the centre of a regular octahedron, at six points of which are situated groups which saturate the six valences of coordination, we can formulate a diagram which represents the simplest of the complex radicals, compared by Werner to the diagram of methane. It remains to determine the manner in which the groups are arranged around the central atom in the case of possible isomers.

The octahedric configuration is fundamental therefore and by means of it we can definitely reduce the distinct isomerisms to variations in the symmetry of the groups situated at the angles of the octahedron. If we imagine a complex radical or system which contains four groups of one kind and two of another opposite and different kind, these may be close together in one of the positions and far apart in the other according to whether they occupy the extremities of an axis or whether they are situated on two different axes of the octahedron. This is the origin of the formulas termed "*cis*" and "*trans*," whose arrangement is demonstrated by the study of optical isomers. Furthermore, forms may be observed which are not superposable (one atom of metal, four groups of one kind and two of the other kind), thus saturating in every manner possible the valences of coordination at the angles of the octahedron. The classic example, borrowed from Werner, is that of two groups which possess two valences of coordination as does ethylene-diamine, which substitutes for the four primordial groups which are in the *trans* position the other two groups. From this are derived as many as three series of different isomers and two kinds of molecular dissymmetry.

All this proves that there exist in the family of complexes isomers capable of decomposition in those modifications which possess optical activity with the peculiarity that the devices by which this result is attained resemble the methods employed in organic chemistry, since they are always applied to the *cis* form, the *trans* form having as yet not been decomposed.

Werner sums up his theories in the following words: "Some mixed salts i. e. those which contain the radicals of inert acids side by side with the radicals of active acids, such as the chloro-nitrates or the bromido-nitrates, lend themselves to the decomposition by crystallization of the racemic inorganic compounds. Instead of the method of decomposition generally employed in organic chemistry, which is based upon fractional crystallization and is often inapplicable to the inorganic compounds, it is always of advantage to make use of a new method which consists in precipitating one of the active compounds from the aqueous solution of the racemic substance."

This is in reality the greatest triumph achieved by Werner's theory, which is particularly applicable to the atoms of the heavy metals whose index of coordination is equal to six: namely, to have demonstrated the existence of the rotatory power in the solutions of these singular bodies whose molecular forms can be represented by two non-superposable octahedrons. In a remarkable address made by Werner before the Chemical Society of France in 1912 the scientist appeared to believe that he had reached the apex of his investigations and stated that his original researches might be considered as the consequence of those which Pasteur inaugurated with his famous studies concerning optical dissymmetry in its relations with molecular dissymmetry—the real starting point of his discoveries.

A new problem has been raised by the existence, which has been demonstrated by experiment, of the rotatory power of the solutions of complexes. It was of the highest importance to discover whether their direction of rotation is always the same and to determine the laws of its variations starting with the existence, in all the complexes which exhibit optical activity, of the radical characteristic of those images which are not superposable but which are nevertheless stereochemical forms. The Zurich professor has demonstrated by important experiments that the direction of the rotation of the plane of polarization depends upon the nature of the radicals which occupy the two other places of coordination of the central atom and upon its own nature. Werner has formulated the following important law: "The series of active isomers which give with the same active acids the least soluble salts exhibit the same stereochemical configuration as the characteristic radical." And this law, with its demonstrations, is connected with observations regarding the directions of the rotation; it agrees with all the knowledge concerning this problem which we possess up to the present time and demonstrates the relationship between the rotatory power and the optical activity of complexes and their constitution.

Thanks to a very considerable number of measurements we now know something about the causes which influence the rotatory power of complexes. The limits of its variations are very extensive and all values are found within them; the influence of the groups united to the central atom is obvious at once. It is very evident and easy to observe that the nature, the positions, and the individual value of the bonds of union are concerned. And as for the nature of the central metallic atom we need only measure the rotatory power of the complex molecules of cobalt, of platinum, of chromium, and of many others, to perceive how closely the direction and the value of the rotary power of the stereochemical complexes depends upon the nature of the metal. The concentration of the solutions is also significant and with respect to this it is believed that the strongest degree of rotatory power corresponds to the weakest degree of condensation, a fact which is explained by the greater amount of dissociation which exists in dilute solution, i. e. by the activity of a greater number of ions. We may add also the influence of a certain factor whose numerical value has not yet been measured and which appears to depend upon the relation which unites the central atom with the groups which saturate its valences of coordination. It may be said finally that in all cases metastable systems are concerned. This completes our sketch of the main features exhibited in the isomerisms of the inorganic complexes.

Radium vs. Meso-Thorium in Luminous Paints

In 1905, Han discovered meso-thorium. The increasing uses of radium for medical work and luminous paint has made the question of radium substitutes an important one. During the war, radium found uses in the dials of instruments on airplanes, electric push-buttons, door numbers, and in a variety of other small ways. As a substitute for radium, meso-thorium is of first importance. It is a radio-active element found in thorium minerals and monazite sand in particular. In the manufacture of paint, the freshly-extracted element is allowed to ripen for several months. During this period, the alpha radiation required for luminous paint becomes much stronger. For medicinal purposes, it may be used within a few days, as the beta and gamma radiation grows rapidly. For luminous paint purposes, the life of meso-thorium is from five to six years, while that of radium is 1,600 years. During this period, radium decays one-half. For products of equal activity, the price of meso-thorium varies from 40 to 60 per cent. of that of radium. For medicinal purposes, radium is much better than meso-thorium, while for luminous paints to be used on objects which themselves have a short life, meso-thorium is much cheaper and equally good.

Canadian sources of Monazite, as given in Geological Survey Reports, Ottawa, Memoir 74:

The mineral is described as a phosphate of cerium, lanthanum, didymium, sometimes with silicate of thorium. It has been discovered in British Columbia on the Quesnel River, about eight miles above its junction with the Fraser River. In Nova Scotia, it occurs in Lunenburg County, near Lake Ramsay. In Quebec, it has been found at the Villeneuve mines in Villeneuve. No other localities are given by the Geological Report. —*Can. Chem. Jour.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

Published by Scientific American Publishing Co.

New York, Saturday, April 26, 1919

Munn & Co., 233 Broadway, New York

Charles Allen Munn, President; Orson D. Munn, Treasurer
Allan C. Hoffman, Secretary, all at 233 Broadway

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 5.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Scientific American Publishing Co.

233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents

, 1919

to six
g this
equal
40 to
rposes,
le for
selves
r and

ogical

erium,
f tho-
bia on
junc-
occurs
uebec,
neuve.
eport.

AN

o.

asurer

$5.00
5.00
ntries,

eck.

blish
stin-
arti-
and
ught
.

uary
Com-
N. Y.
Com-
ubse-
by
way,

in a
anch
osed
thor-
ap-
the
ical,

who
ap-
ited

Y.